RELEVANCE OF ULTRASOUND IN THE DIAGNOSIS AND MANAGEMENT OF MALIGNANCY OF THE THYROID

DEPARTMENT OF ENDOCRINE SURGERY

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CERTIFICATE

This is to certify that this dissertation entitled **"Relevance of Ultrasound in the Diagnosis and Management of Malignancy of the Thyroid"** is a bonafide dissertation done by **Dr.G.Mohana Priya,** Post Graduate at Department of Endocrine Surgery in Madras Medical College, under my supervision and guidance and is submitted to the Tamil Nadu Dr.M.G.R. Medical University, Chennai in partial fulfillment of the requirement for the M.Ch (Endocrine Surgery) degree.

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DECLARATION

I, **Dr.G. Mohanapriya** hereby declare that the dissertation entitled **"Relevance of ultrasound in the Diagnosis and Management of Thyroid Disorders"** was done by me at the Department of Endocrine Surgery, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai in partial fulfillment of the M.Ch. Degree – Branch – IX Endocrine Surgery from March 2010 to January 2012.

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ABSTRACT

Background

The recent prevalence of ultrasonography has facilitated the early detection and qualitative evaluation of thyroid nodules – to differentiate between thyroid carcinoma and benign nodule, between metastatic lymph node and reactive node. It has moved from the suite of the radiologist to the surgeon's office. The aim of the present study was to evaluate the relevance of SPUS in the diagnosis and surveillance of malignancy of the thyroid.

Methods

Surgeon performed ultrasound for 389 patients and the data of 350 patients who underwent total thyroidectomy was compared with the report of the RPUS, FNAC and HPE. The sensitivity, specificity, positive predictive value, negative predictive value for each was calculated. The nodule characteristics – echogenicity, margins and calcifications were analysed for correlation with malignancy.

Conclusions

Surgeon who is more familiar with the anatomy and patho-physiology of thyroid disorders triages the nodule better. Multivariate analysis of nodule characteristics showed that heteroechogenicity, irregular margins and microcalcifications had a greater association with DTC after adjustment for the other characteristics.

ABBREVIATIONS USED

1.	USG	-	Ultrasonogram
2.	SPUS	-	Surgeon Performed Ultrasound
3.	RPUS	-	Radiologist Performed Ultrasound
4.	FNAC	-	Fine Needle Aspiration Cytology
5.	HPE	-	Histopathological Examination
6.	PTC, Pap Ca	-	Pipillary Corcinoma Thyroid
7.	SNT	-	Solitary Nodule of the Thyroid
8.	MNG	-	Multinodular Goitre
9.	OAH	-	Oncocytic Adenomatoid Hyperplasia
10.	TSH	-	Thyroid Stimulating Hormone
11.	AITD	-	Auto Immune Thyroid Disease

INTRODUCTION

Most of the patients attending the outpatient ward of Endocrine Surgery Department present with nodular goiter. Of this 90% of the cases are benign. It is essential for the Endocrine Surgeon to identify the remaining 10% of the malignant cases at an early stage.[29] so that they can be managed appropriately with reduced morbidity.

Clinical symptoms of hoarseness of voice, pressure effects and signs of fixity appear much later. FNAC is an useful clinical adjunct distinguishing the benign goiters from the malignant ones, misses malignancy in about a third of the lesion[57] and the negative predictive value is never a 100%. Ultrasonogram is an extension of the clinician's arms and the shadows cast help in distinguishing the benign nodules from the malignant ones.[34] Moreover it is quick, painless, inexpensive, reproducible and safe to all patients without any radiation hazard. It can also be combined with FNAC to improve the diagnostic accuracy[67]. However the interpretation of images is operator dependent. Apart from this, it is also useful in assessing the regional lymph nodes which is important for determining the extent of lymph node dissection and evaluating the biologic behavior including prognosis.

When a surgeon, who is more acquainted with the anatomy of the neck[56] performs an ultrasound, obtains more real time information from the images, which helps in making accurate management decisions and saves the patients effort and time in approaching another consultant.

The objective of this study is to evaluate the effectiveness of ultrasonogram in identifying malignancy of the thyroid for its early and effective management and in its surveillance.

REVIEW OF BASIC SCIENCES

Evolution of Ultrasound

The roots of sonography can be traced back to the ancient Greeks. Pythagoras invented the sonometer which was used to study musical sounds. Boethius was the first to compare sound waves produced by dropping a pebble into water.

Ultrasound was conceived in 1877, when the French Physicist Pierre Curie discovered Piezo electric effect. The sinking of the Titanic on its maiden voyage in 1912 made people want to know how to detect submerged objects. Constantin Chilowsky came up with the idea for an ultrasonic detection system, which was brought to the notice of the French government. As instructed by the French government, Paul Langevin, student of the Curie brothers, used the Piezo electric effect and invented the SONAR in 1917.

Soviet Physicist Sergei Sokolov used ultrasound for industrial purposes including detection of flaws in metals.

In 1920's and 30's ultrasound was used for physical therapy, for sterilization of vaccines and for cancer therapy in combination with radiation therapy.

Karl Dussik, a neurologist in Austria is the first physician to employ ultrasound in medical diagnosis in 1940's. He along with his brother used 'hyperphonography' to locate brain tumours and cerebral ventricles. Later George Ludwig used ultrasound to detect gallstones.

Douglas Howry a radiologist, concentrated on the development of B-mode equipment that compared cross sectional anatomy to gross pathology in 1948. In 1950 John Reid and John Wild built a linear hand held B-mode instrument. For breast tumours Joseph Holmes in 1951, produced the first 2D B-mode linear compound scanner.

Wolf Keidel, Inge Edler and Hellmuth Hertz of Sweden are considered the Fathers of echocardiography. In 1956, Robert Rushmer a physiologist along with two engineers Dean Franklin and Don Baker led to the development of continuous wave Doppler.

The late 60's and early 70's is referred to as the sonic boom. During this period 2D echo was introduced by Klaus Bom. Real-time ultrasound started to appear in the early 1980. In the 1990's the field went one step further with 3D and 4D images.

In the early days scanning equipment was very large. The invention of the transistor and integrated circuitry made it possible to build smaller and smaller equipment. In the 1980's probes became smaller and image resolution improved significantly.

Historical perspective of thyroid ultrasound

Sonography commands a central role in the evaluation, diagnosis and treatment of thyroid disorders. The initial use came at a time when palpable thyroid nodules were surgically excised to establish a pathologic diagnosis. In the late 1960's USG was used to differentiate between solid and cystic nodules and to measure and track nodule size.[58] The first use of ultrasound to examine the thyroid grand was by Yamakawa and Naito in 1966 to calculate thyroid volume and weight. Then Fujimoto used to study structural alterations in the gland. This was before the advent of the high frequency probe when a water bath technique was used – enough water was used to permit the thyroid tissue to fall within the focal range of the transducer – probably 3 to 6 cm. Subsequently commercially available polymer pads were used to reduce the reverberation artifacts in a water bath, in the stand off technique. With the availability of high frequency probes and high viscosity couplants, the direct contact technique has come into vogue.

Using conventional ultrasonography clinicians were able to differentiate between cysts and cystic degeneration in an adenoma, solitary nodules from multinodular goiters and to detect the presence of thyroiditis with greater than 90% accuracy[47].

Later investigators began studying whether they could improve surgical and medical decision making by identifying malignant features of thyroid lesions.[31] The role of thyroid ultrasound has continued to expand over the past 40 years and is currently recommended in the evaluation of all palpable nodules by the American Thyroid Association (ATA). The American

Association of Clinical Endocrinologists (AACE) and the Association Medici Endocrinologi (AME).[10,16]

Advances in ultrasound engineering and electronic technology in the 1990s has made ultrasound more user friendly. Ultrasound which was once in the purview of the sonographers, who took spot films that were interpreted by the radiologist for the clinician has now moved into the office of the surgeon, who takes history, examines the patient and allows ultrasound findings to be integrated with the patients clinical findings. This cuts the cost of the patient going to another specialist and provides valuable real time information to the surgeon who appreciates even subtle changes in suspected malignancy.

The recent introduction of small linear phased-array transducers greatly facilitates USG guided FNAB that decreases the number of inadequate biopsies.

Future Use of Ultrasound[33]

Ultrasonography is uniquely portable when compared to CT and MRI, does not carry the risk of irradiation, making it ideal for use in clinical setting.

Laptop sized and palm sized sonograms with better resolution will allow the increased use of ultrasound in the clinical sitting. Objective palpation by elastography will prove to be useful in determining whether a lesion is benign or malignant. Combining this technique with the study of vascular detail using microbubbles would enhance the ability to distinguish benign from malignant tumours.

The promise of coagulating bleeders with HIFU has great appeal and is yet to be perfected. Targeted microbubble delivery of drugs and DNA plasmids with ultrasound's ability to increase cell penetration holds great promise for the therapeutic use of ultrasound.

Basic Physics of Ultrasound

Audible sound waves lie between 20 and 20,000 Hz. Ultrasound uses sound waves with a greater frequency 1 to 30 MHz. Sound waves need a medium to get propagated. The closer the molecules, the faster the sound wave moves through the medium, so bone and metals conduct sound waves well. Air in lung and bowel conduct poorly. Gel or mineral oil must fill the space between the transducer and the patient, otherwise sound will not be transmitted across this gap.

Ultrasonogram utilises the Piezo electric effect and the Pulse-Echo principle. When a crystal like quartz or lead zirconate is electrically stimulated. It changes shape and vibrates thus producing a sound beam that propagates through tissues. The crystal emits the sound wave and then waits for the returning echo reflected from the structures in the plane of the sound beam. When the echo is received, the crystal again vibrates, generating an electrical voltage comparable to the strength of the returning echo.

B-mode is a method of displaying the intensity of an echo by varying the brightness of a dot to correspond to echo strength. Hyperechoic structures appear brighter and hypoechoic tissues are darker than surrounding tissues.

The strength of the returning echo is related to the angle at which the beam strikes the acoustic interface. The more perpendicular, the stronger the echo. Acoustic impedance relates to tissue density, the greater the difference in density between two structures, the stronger the returning echo.

Transducer frequencies vary between 2.5, 3.5, 5 and 7 MHz. Increasing the frequency improves resolution but decreases penetration. The thyroid can be imaged using a 7.5 to 15 MHz probe. The waves close to the skin the Fresnel Zone suffers from the effect of turbulence and resolution here is poor. Beyond the focal zone, the beam widens – Fraunhofer zone where the images are distorted and difficult to see.

Sound waves can be scattered where they do not return to the detector. Reflectors fall into 2 categories. (1) Specular (2) Diffuse. Specular reflector acts like a mirror.[9] It is smooth and large compared to the wavelength of the sound wave. Examples include carotid artery and fluid filled cysts. Diffuse reflectors account for speckled patterns. Sound energy is scattered rather than reflected in coherent manner when the wavelength of sound wave is larger than the size of the reflector.

Diagnostic imaging relies on the return of sound wave energy to the transducer. In addition to the scattering that occurs with diffuse reflectors and the angled reflectance, caused by specular reflectors, another major source of energy loss is attenuation. Absorbance of the sound energy along the path of the wave limits the potential depth of penetration. Tissues absorb sound energy by converting the sound energy into heat. This conversion increases with the frequency of the sound wave and becomes the major factor limiting the depth

of tissue penetration when using higher ultrasonic frequencies. Resolution sets the lower limit on the useful range of ultrasound frequencies for the head and neck region. Absorbance, the chief cause of attenuation, sets the upper limit.

The Physics of Artifacts

Reverberation, multipath, shadowing, enhancement, side lobe and refraction are the most common artifacts in B-mode ultrasound.

Reverberation artifacts occur when the sound waves repeatedly reflect between two interfaces with significantly mismatched impedences. This commonly occurs at the tracheal rings. The anterior soft tissue to cartilage interface and the posterior cartilage to air interface lead to serial reflections with a resulting artifactual increase in apparent path length.

Multipath artifacts occur at specular reflectors altering the apparent position and shape of objects. The small specular reflectors such as carotid artery, rarely lead to multipath artifacts. Shadowing artifacts are due to attenuation of sound energy leading to little or no reflections being returned from deeper objects because of lack of sound energy. This can be due to thick muscles or calcifications in the thyroid.

Enhancement can occur when attenuation of overlying tissues is less than surrounding tissues. For example fluid filled cysts and blood within blood vessels have lower attenuation than surrounding soft tissues leading to enhancement of deeper tissues.

Side lobe artifacts arise when there are strong reflectors just outside the primary beam path. Reflection off a cyst wall outside the sonographic plane can make it appear that there is a mass within the cyst.

Refraction artifacts occur when there is a change in direction of propagation when a sound wave passes between two media with different propagation velocities. This moves the position of the object resulting in spurious duplicates and can occur at muscle edges.

Thyroid ultrasonography goals and indications[36]

- To better assess palpable thyroid nodules.
- To determine whether nodularity is present in the patient with an equivocal or difficult physical examination.
- To determine whether characteristics associated with malignancy are present.
- To screen for thyroid lesions in patients with other diseases in the neck, such as hyperparathyroidism, who are undergoing treatment planning.
- To assess the thyroid and the extra thyroid neck in the patient with thyroid cancer before treatment. To identify thyroid features associated with diseases including thyroiditis and Graves disease.
- To help teach regional anatomy and the art of thyroid palpation.
- To monitor foetal thyroid development in utero.
- To detect goiter as a sign of iodine deficiency.
- To screen family members of patients with familial forms of thyroid cancer.

- To facilitate FNA biopsy of a nodule. To assess the remainder of the thyroid gland in the patient with a palpable thyroid nodule.
- To screen for thyroid lesions in patients who have been exposed to radiation.
- To objectively monitor nodules, goiters or lymph nodes in patients undergoing treatment or observation of thyroid disease.
- To monitor treated patients with thyroid cancer for early evidence of recurrence in the thyroid bed and cervical lymph nodes.
- To facilitate therapeutic procedures such as sclerotherapy or laser ablation of thyroid nodules.
- To detect undescended thyroid or thyroid agenesis.
- To assess the size and location of the neonatal thyroid.
- To refine management of patients on therapy such as antithyroid medications.

Advantages of Ultrasound

1. Versatile
2. Speed of diagnosis
3. Easily available
4. No risk of ionizing radiation
5. Portable
6. Low cost
7. Offers dynamic real time images.

Disadvantages

1. Gives only a clue to the diagnosis, does not offer pathological diagnosis.
2. It is operator dependent.

Side effects

Thermal heating of tissues and cavitation effects are seldom a problem with the frequencies and output energy used in diagnostic medicine.

SONOGRAPHIC ANATOMY OF THE HEAD AND NECK

A thorough knowledge of the anatomy of the head and neck is essential to understanding the ultrasonographic appearance of this region. This makes the surgeon better suited for performing the ultrasound.

An ultrasound examination should follow a systematic and thorough course to ensure that all the structures of the neck from clavicle to mandible are evaluated. The examination is performed in both the axial and longitudinal planes.

The sonographic appearance of fat is hyperechoic relative to muscle, which is hypoechoic. Cervical fascia is very echogenic and appears as a whiteline that demarcates the structures from one another. Mucosa is also echogenic. Arteries are anechoic and pulsations can often be seen. Veins are also anechoic and are compressible by pressure with the probe.

Normal thyroid parenchyma is hyperechoic and homogenous compared with the relatively hypoechoic strap muscles, that border the gland anteriorly.

Interruption of the fascia surrounding the gland should alert the sonologist to the possibility of extra thyroidal extension by a malignancy. There is an anechoic space between the thyroid and capsule, representing the capsular vessels.

There is a slight asymmetry between right and left thyroid lobes. The pyramidal lobe is not commonly seen because of its small diameter. The trachea lies posterior to the thyroid and the common carotid arteries border the gland laterally on each side. The thyroid is bounded by the sternocleidomastoid anterolaterally and by the oesophagus and longus colli muscles posteriorly.

The size of the thyroid is influenced by factors such as alcoholic cirrhosis, renal failure, smoking, parity, iodine intake, TSH, use of OCP, gender, age, BMI. Lean body mass and body surface area are the major determinants of thyroid size.[27]

Normal thyroid measurements

Longitudinal dimension	-	40 to 60 mm
Anteroposterior diameter	-	13 to 18 mm
Thickness of the isthmus	-	4 to 6 mm

The gland is enlarged if the AP diameter is more than 2 cm and the isthmus is thicker than 10 mm. Thyroid volume is calculated on an ellipsoidal model[6]. The height, width and depth are multiplied by a correction factor of 0.529 or $\pi/6$ and the volume of both lobes is added. The average volume is between 12 to 40 $cm^{2.}$

In South Indian population the volume of normal thyroid is much less, each lobe is about 5 ml in volume in euthyroid individuals though WHO recommends a normal volume of 18 ml for women and 25 ml for men.[49]

The oesophagus is seen on the posterolateral aspect on the left side. The air column and saliva in it appears echogenic with the surrounding muscle being hypoechoic, appearing like a target or bull's eye. The patient can be made to swallow to visualize the oesophagus which relaxes.

The normal parathyroid is seldom seen. Parathyroid adenomas appear as discrete oval nodules that are homogenously hypoechoic relative to the thyroid gland and the echogenic thyroid capsule may be visible separating these structures. Parathyroid glands are relatively incompressible compared with the adjacent soft tissue. Thus gentle compression over a suspected parathyroid can increase the conspicuity of subtle lesions A polar feeding vessel can be picked up by Doppler.

Concurrent thyroid disease can result in several imaging pitfalls. Acoustic penetration may be limited in the setting of large multinodular glands, obscuring the parathyroid tissue, posteriorly positioned thyroid nodules can be confused with the parathyroid especially when it is totally within the thyroid capsule.

Imaging of cervical lymph nodes[13]

Until the early 1990's cervical lymph node classification was based on anatomic location with the anterior nodal groups labeled as submental,

submandibular, internal jugular, supraclavicular, posterior triangle and parotid. This classification was cumbersome and a better topographic classification was adapted to aid in mapping nodal surgical intervention. The sonographic landmarks (proposed by the American Joint Committee on cancer and the American Academy of Otolaryngology) used in dividing the neck are slightly different from the anatomical landmarks.

The lateral compartment neck nodes (levels II through IV) are found around the jugulocarotid vascular bundle and may be under the sternocleidomastoid muscle. Level II-lymph nodes are located above the level of the hyoid bone to the base of the skull. Level III-nodes are between the levels of the hyoid bone and the cricoid cartilage. Level IV-nodes are below the level of the cricoid cartilage extending to the clavicle. Level V – transverse cervical chain and posterior triangle lymph nodes. The central compartment or anterior neck lymph nodes level VI are located posterior and inferior to the thyroid gland adjacent to the trachea and oesophagus. The compartment is bordered laterally by the medial carotid sheaths, extends superiorly to the hyoid bone and inferiorly to the sternal notch. Level VII are the superior mediastinal nodes.

The landmarks mentioned can be either imaged sonographically or palpated.

Ultrasound imaging of normal lymph node

Normal lymph node morphology is characterized by a connective tissue capsule surrounding an outer cortex with the densely packed lymphocytes

forming lymphoid follicles and an inner medulla containing the blood vessels, lymphatic sinuses and connective tissue.

About 70% of normal subjects can harbor one or more normal lymph nodes. Therefore it is essential to appreciate the different imaging characteristics of benign and malignant lymph nodes. The evaluated parameters should include size, shape, presence of an echogenic hilus and a hypoechoic cortex, vascularity, cystic change, calcifications.

The size of the node may vary according to the region of the neck. A level II reactive node may appear larger due to hyperplasia from repeated oral infections. The long axis measurement may go upto 18mm in this region. The short axis diameter in this region varies less and does not exceed 8 mm. In other areas, it is 5 mm.

A normal lymph node is oval in shape and a short to long axis ratio is less than 0.5 mm. However normal nodes in the submandibular and parotid region may be round and the nodes in the central compartment may be round in reaction to chronic autoimmune thyroiditis.

A normal node exhibits a hypoechoic cortex with an echogenic central hilus. This hilus is often visualized in nodes larger than 5 mm. The echogenicity is due to hilar fat, which becomes prominent with age and the presence of intranodal arteries, veins and lymphatic sinuses. Hilar vascularity may be detected in 90% of normal lymph nodes with a transverse diameter greater than 5mm. Smaller nodes appear avascular.

Sonographic features in thyroid disorders

The superficial location of the thyroid and dramatic improvements in the resolution, have made ultrasound the modality of choice in diagnosing thyroid disorders. It is important for the surgeon to understand the spectrum of sonologic appearances of the common thyroid disorders.

Goitre due to endemicity [52]

The gland is uniformly enlarged and it may appear hypoechoic due to lack of iodine. There are no special features to call it endemic goiter.

Colloid goiter

Initially, the gland is diffusely involved, and there is uniform enlargement. Accumulation of colloid within the follicular cells, can be seen as small cystic spaces giving the gland a honeycomb or spongiform pattern. The small cystic spaces, which are anechoic coalesce to form larger cystic spaces and cystic nodule. Rarely are the cysts simple, virtually all cystic nodules have a solid component which has to be distinguished from a cystic, necrotic malignancy.

When ultrasonography of a fluid filled cyst is done, the posterior wall of the cyst and area distal to the cyst is bright or enhanced. Some solid nodules are so hypoechoic, that they mimic a cyst, but careful examination slows that the posterior enhancement is lacking.

A prominently cystic lesion is more likely to be benign, as most of the cystic papillary carcinomas have a cystic component that rarely exceeds 50%.

Degeneration and Haemorrhage in a colloid nodule leads to dystrophic calcification, these calcifications are quite dense, reflect sound waves causing bright images on the ultrasound screen. They are large coarse, the area distal to the calcification appears dark due to blockage of sound waves causing acoustic shadowing.

Occasionally a bright spot can be seen in a nodule that resembles a calcification, but instead of shadowing, a blurred brightness is seen distally, the so called 'comet tail' or 'ring down' effect, also referred to as a 'cat's eye' – a sign of colloid crystal in a benign colloid nodule.

Sometimes, the cyst can be complex with septations.

Hashimoto's thyroiditis

It is the most common form of thyroiditis with a 9:1 female/male ratio. Patients typically present with a painless lobular, diffusely enlarged thyroid gland often with hypothyroidism. Because not all patients have antithyroid antibodies and many are euthyroid at the time of diagnosis, ultrasound is a useful adjunct, when the disease is unsuspected clinically.

Lymphocytic infiltration of the gland with follicle destruction leads to hypoechogenicity and the degree of hypoechogenicity correlates with the likelihood and severity of hypothyroidism.[32]

In the initial stages the gland is heterogenous and has a coarse echo texture compared with normal thyroid. There is either normal or increased vascularity when imaged with colour Doppler and the increased vascularity is associated with the development of hypothyroidism caused by trophic stimulation of the gland by TSH[24]. Later, there may be decreased vascularity.

The presence of hypoechoic micronodules ranging in size from 1 to 7 mm surrounded by an echogenic rim of fibrosis is specific for the disease with a 95% PPV. As the disease progresses, the gland developes echogenic linear bands of fibrosis which become confluent and thicker. Occasionally Hashimoto's thyroiditis may present as a focal nodule[1] or nodules with diffusely altered parenchyma or in a sonographically normal gland. The most common form of a thyroid nodule is a homogenously hyperechoic solid nodule, the so called 'white knight'[5] likely representing a regenerating nodule. Sometimes bright blocks separated by dark bands resembling giraffe's hide as described by Bonavita can also be present. Ocassionally ill defined margins, cystic changes and intranodular calcifications are also observed.[30]

Several enlarged and atypical appearing central compartment lymph nodes can be found adjacent to the lower poles of both lobes.[50] Although reactive lymph nodes are seen in Hashimoto's thyroiditis, the presence of microcalcifications, cystic change, peripheral vascularisation, echogenic lymph node cortex, loss of fatty hilum and round shape are features concerning metastasis.

Graves disease

The disease is caused by binding of stimulatory thyroid auto antibodies to the TSH receptor on the follicular cells, resulting in increased hormone synthesis and secretion and growth of the thyroid gland. Diffuse hypertrophy and hyperplasia of follicular cells with colloid depletion and lymphoid infiltration are seen at histology.

There are no specific grayscale ultrasound findings. There is diffuse enlargement, convex bowing of the anterior gland margin and mild textural coarsening. The echogenicity may be normal, but may be decreased to variable degrees because of increased intrathyroidal blood flow, functional changes in thyroid follicles with increased cellularity and decreased colloid content. This may be similar to Hashimoto's disease but is less heterogenous and the contour is less lobular. Focal nodules and malignancy can also be picked up in Graves disease.

Early colour Doppler studies, suggesting the 'thyroid inferno' pattern[43] due to increased vascularity may be highly specific for the disease. Normal thyroid parenchyma shows occasional spots of flow on colour Doppler; peak systolic velocities between 15 and 30 cm/s in the intrathyroidal arteries. In untreated active Graves disease, the thyroid blood flow is 15 fold higher.[4]

Saleh and colleagues have demonstrated a threshold peak thyroid artery systolic velocity of more than 60 cm/s, had a 100% specificity and 80% sensitivity for distinguishing Graves from other causes of diffuse toxic goiter.

A cut off of 4% greater systolic flow could be used to discriminate Graves from destruction induced thyrotoxicosis.

Colour Doppler may also be used to determine the response to treatment[7]. A significant decrease in flow velocities in the superior and inferior thyroid arteries after treatment has been reported. Low thyroid echogenicity and high flow in the thyroid artery and parenchyma may be specific for prediction of relapse of hyperthyroidism. Radioiodine therapy results in scarring and atrophy of the thyroid gland.

Simple multinodular goiter

Several complex interactions between environmental, genetic and endogenous factors causes diffuse simple goiter. Haemorrhagic necrosis and scarring of connective tissue limits the polyclonal growth of follicular cells resulting in nodularity.

This results in replacement of thyroid parenchyma by isoechoic nodules with haemorrhage, necrosis and colloid accumulation causing variable cystic changes. Dystrophic calcifications result in coarse calcifications being seen.

The risk of malignancy in each individual nodule within a multinodular gland decreases by a rate proportional to the number of nodules.[14] The American Thyroid Association recommends analyzing the sonographic features of individual nodules in a multinodular goiter to triage the nodules for malignancy.

Follicular adenoma

Adenomas comprise 5% to 10% of thyroid nodules. They are often functional, but rarely hyperfunctional. True adenomas have a capsule as opposed to hyperplastic nodules which do not. They can be hypoechoic, iso or hyperechoic. Rarely they can also demonstrate cystic degeneration and coarse calcifications. Doppler vascular analysis visualizes central branches of vessels coming from the capsule into the center of the adenoma, so called 'spoke and wheel' arrangement.

Ultrasound characteristics of malignant lesions

Most of the nodules are benign. Only about 10% are malignant.

Risk factors for malignancy include male gender, advanced age, exposure to ionizing radiation, family history of thyroid cancer.

The features of a nodule which suggest malignancy[26]

1.	Margins	Blurred, ill defined
2.	Halo rim	Absent
3.	Shape	Irregular, spherical tall
4.	Echo structure	Solid
5.	Echogenicity	Hypoechoic
6.	Calcifications	Microcalcifications
7.	Vascular pattern	Intranodular, hypervascular
8.	Elastography	Decreased elasticity

Nodule Size

Does not predict malignancy significantly. The risk of malignancy is about 10% and is the same in both nodule size more than or less than 1 cm[37]. Risk of sub centimeter nodules increases when there is a family history of malignancy, exposure to ionizing radiation, history of thyroid cancer or nodules avid for FDG on PET scan.

Margins and halo

Benign lesions have a circumferential halo which represents compressed thyroid tissue and a capsule. Malignant lesions may not possess a halo or it is partially present. A blurred or a ill defined margin increases the risk of malignancy.[28]

Nodule Shape

Spherical, irregular and nodules that are more tall than wide[26] are likely to harbor cancer.

Echo structure

Malignant nodules are more likely to be solid or have mixed echogenicity.[28]

Echogenicity

The echogenicity of the thyroid nodule should be compared with that of surrounding thyroid tissue. Benign nodules are slightly hypoechoic while malignant ones are markedly hypoechoic.[28]

Calcifications

Eggshell calcifications result from previous haemorrhage and degenerative change and are considered a benign feature. 45% - 60% of malignant nodules may show microcalcifications[26] which are less than 2mm and do not cause posterior acoustic shadowing. Coarse calcifications are more likely to be benign, while some of the long standing malignancies also show coarse calcifications.

Vascular pattern

Chammas[8] and colleagues classified thyroid nodules according to the pattern of vascularity seen with power Doppler into five types : absent blood flow, perinodular flow only, perinodular flow greater than central blood flow, mainly central nodular flow, central flow only. Nodules with exclusively central blood flow or central flow greater than perinodular flow had a higher incidence of malignancy.

Elastography

It is the ultrasound measurement of tissue elasticity, a mechanical property reflecting the deformation or distortion of the tissue in response to the application of external compression. The displacement of the strained tissue is estimated by tracking the echo delays in segmented waveforms recorded before and after quasistatic compression. The sensitivity and specificity varies between 82 to 100% and 81 to 97% respectively.[45]

Papillary carcinoma

It is the most common thyroid malignancy representing 70 to 80% of the thyroid cancers. Ultrasound features include solid, hypoechoic lesion with microcalcifications, cystic components may be present within a solid lesion, ill defined margins are common. Doppler reveals disorganized hypervascularity. Microcalcifications may be the most specific for PTC because psammoma bodies, composed of tiny laminated spherical collections of calcium that reflect sound waves appear as tiny bright foci.

Follicular carcinoma

It accounts for 10% of thyroid malignancies. Unlike PTC it is more likely to spread via hematogenous routes, accounting for higher incidence of distant metastasis and poor prognosis.

The lesion is typically, solid, hypoechoic and homogenous. Cystic change and calcifications are rare and more often seen in benign lesions. Hypervascularity is seen on Doppler examination. A halo is often seen, but it is not complete and the thickness is more than 4 mm.

Hurthle cell carcinoma

They account for about 3% of thyroid cancers and 20% of these tumours are malignant. They are more aggressive than PTC. On ultrasound, Hurthle cell tumours are solid, both hypoechoic and hyperechoic with an irregular border. They do not have calcifications.

Medullary carcinoma

Account for 5% of thyroid cancers. They arise from parafollicular 'C' cells and are concentrated in the superior poles. The lesion is solid and hypoechoic, and has hyperechoic foci, representing amyloid deposition, and calcification. These foci may appear within affected lymph nodes.

Anaplastic carcinoma

It is the most aggressive type of thyroid cancer. Ultrasound shows a diffusely hypoechoic lesion, often infiltrating the entire thyroid lobe with areas of necrosis or ill-defined calcifications. Invasion into surrounding vessels or soft tissue is often seen.

Lymphoma

Accounts for less than 5% of thyroid malignancies. Non Hodgkin lymphoma is the most common type and is associated with a history of Hashimoto's thyroiditis. The clinical symptom of pain is often lacking. Local soft-tissue and vascular invasion are common. It may appear as a focal lesion or a diffuse abnormality involving the entire gland. The involved tissue is usually heterogenous and hypoechoic and may be mistaken for anaplastic carcinoma. Pseudocysts with posterior enhancement are sometimes seen.

Metastalic disease

Lymphoma, melanoma, renal cell carcinoma, lung, colorectal cancer and breast cancer metastases have been described. Although they have a variable

sonographic picture, most of them are hypoechoic with well defined margins and lack of halo and calcifications. They are usually multinodular, occasionally can occur as solitary nodule or a heterogenous pattern when the thyroid is diffusely involved.

Table 1 : FNAC AND HPE Features of thyroid disorders

Non – neoplastic disorders of the thyroid

Gross findings	Histology	Cytology	Ultrasound Features
i. **Adenomatoid nodule :** Enlarged gland with multiple nodules of variable size Cut section gelatinous Degenerative changes seen	Capsule absent or pseudo capsule Large follicles distended with colloid Epithelial cells flattened Oxyphilic cells may be present Cellular nodules with increased cellularity and little colloid papillary fronds seen.	low cellularity and abundant colloid Follicular epithelium in *honey comb pattern* Haemosiderin laden macrophages may be seen Coexistence of involutional and hyperplastic follicular cells	Iso, hyper or hypoechoic nodules with or without degeneration, cystic spaces with coarse calcifications comet tail appearance
ii. Acute thyroiditis: Erythematous gland soft with pockets of purulent exudate or necrosis	Neutrophilic infiltration, Micro abscesses, foci of necrosis, vasculitis, organisms demonstrated.	Neutrophils seen	Hypoechoic gland complex fluid containing bright-echoes from gas suggests an abscess
iii. Granulomatous (Dequervains) Thyroiditis Asymmetric enlargement vague nodularity, firm.	wholegland nodular ***(i) Early stage:*** Follicles disrupted by lymphohistiocytic infiltrate with neutrophils in lumen ***(ii) Late stage :*** multinucleated giant cells more prominent Extensive destruction of follicular epithelium obscuring follicle centred disease. ***iii. Resolution :*** Follicle	Lymphocytes, histiocytes, plasma cells multinucleated giant cells seen Colloid and follicular cells scant	Hypoechoic areas along the long axis of the gland corresponding to the patients pain area

Gross findings	Histology	Cytology	Ultrasound Features
	regeneration, little fibrosis remains		
iv. Reidel's Thyroiditis : Pale *woody thyroid* with ragged borders diffuse enlargement and adherent to strap muscles & soft tissues	Extension into soft tissues with lack of interface Extensive fibrosis patchy lymphocytes, plasma cells, monocytes, neutrophils Rare follicles *occlusive phlebitis* with thickened walls and myxoid changes	Paucicellular to acellular aspirate scant material with atypical spindle cells	Hypoechoic gland with fibrous septations with pseudonodular morphology, encasement of jugular vessels
v. Hashimoto's thyroiditis: Gland grossly enlarged, pale grey to white, consistency like lymphoid tissue, distinct modules in long standing cases	Diffuse infiltrate with lymphocytes, plasma cells histiocytes, rarely giant cells. Follicular atrophy with oxyphilic metaplasia, lympho epithelial cysts	Mixed polymorphic lympho plasmo cytic infiltrate. Mixed multinucleated Giant cells and histiocytes. *Oxyphilic* epithelial cells – *Askanazy* cells, Scant colloid	Hypoechoic gland with swiss cheese, giraffe hide, bag of marbles appearance. Late cases may show fibrous septations with pseudonodular morphology
vi. Graves disease: *Beefy red,* diffuse enlargement Treated cases may appear nodular	Highly cellular, little colloid Hyperplastic redundant follicular epithelium with papillary infolding, cells columnar. Follicular nuclei round, enlarged and basally oriented. Scalloping if colloid present. Accentuation of lobular pattern Patchy inflammatory infiltrate	Highly cellular minimal or no colloid sheets of follicular cells having abundant granular cytoplam *(Flame cells)* nuclei with compact chromatin	Hypoechoic gland with convex bowing of the anterior margin. Doppler – thyroid inferno pattern

Gross findings	Histology	Cytology	Ultrasound Features
vii. Dyshormonogenetic goitre diffuse enlargement later nodular, Nodules opaque	Hypercellular with microfollicular or solid pattern, little colloid. Fibrosis prominent, cytologic atypia in parenchyma between nodules	Highly cellular with small sheets and clusters of follicular epithelial cells, little colloid, cytoplasmic oxyphilia Nuclear atypia	No specific features
II. Benign neoplasms			
(i) Follicular adenoma: Thin capsule well demarcated interior distinct from parenchyma	Intact capsule, No invasion Smooth muscle walled vessels present in fibrous connective tissue, colloid present. Variants – Trabecular, oncocytic, fetal, embryonal, signet ring cell.	Cellular smears, colloid present follicular groups without nuclear features of papillary carcinoma	Adenomatoid nodule Follicular carcinoma Papillary carcinoma Trabecular neoplasm, Metastatic carcinoma
III. Malignant neoplasms :			
i. Papillary carcinoma: Grey white firm mass with irregular borders often circumscribed. *calcifications* with *gritty* surface. Extrathyroidal capsular extension can be seen	Variable growth pattern, complex papillae, elongated and twisted follicles, invasive growth. *Psammoma* bodies. Bright eosinophilic colloid intramural sclerosis, crystals, giant cells in colloid, cells show nuclear overlapping and crowding contour irregularities and grooves, folds or *crescent moons*, *intranuclear inclusions.*	Cellular aspirate Papillary and monolayered sheets of cuboidal cells Enlarged overlapped nuclei, *powdery nuclear chromatin*, *nuclear grooves* and intranuclear inclusions *Ropy bubble gum colloid*	Hypo or hetero echoic nodules with irregular margins with fine calcifications occasionally coarse calcifications can be seen
ii. Follicular carcinoma: Solitary encapsulated	*Capsular or vascular invasion* Cellular with follicular, solid and trabecular growth. Enlarged cells with round to oval nuclei *Oncocytic* cells have large centrally placed *macronucleoli* within the nuclei	Cellular aspirate dispersed micro follicular arrangements of cells forming small ring like structures colloid is scant	Hypoechoic nodule, homogenous with thick irregular capsule

Gross findings	Histology	Cytology	Ultrasound Features
iii. Medullary carcinoma: Unilateral solitary Encapsulated with tan yellow soft to firm cut surface calcifications seen	C-cell hyperplasia Entrapment of benign follicular epithelial cells. Round to oval spindle to plasmacytoid cells. round to oval nucliei with stippled *salt and pepper* nuclear chromatin Intranuclear cytoplasmic inclusions	Cellular aspirate Single cells & loosely cohesive clusters. Colloid absent Amyloid present Giant multinucleated cells. Eccentric nucleus placement stippled to coarse nuclear chromatin	Coarse echo texture with coarse calcifications
iv. Primary thyroid lymphoma Soft to firm, multinodular cut surface bulging, *tan and fish – flesh,* Homogenous mottled extension into thyroidal soft tissue	Lymphocytic thyroiditis Atypical small lymphocytes plasma cells *Dutcher bodies* and *Russell bodies* lymphoepithelial cells are diagnostic	Marginal zone B cell lymphoma dispersed, non cohesive admixture of lymphocytes centrocytes, monocytoid B cells, immunoblasts. large B cell lymphoma hyper cellular dyscohesive, large atypical neoplastic cells.	Focal lesion or a diffuse abnormality of entire gland. Tissue with pseudocysts with posterior enhancement seen.

VARIANTS OF PAPILLARY CARCINOMA

Follicular variant

Encapsulated, small tight follicles with scant, hypereosinophilic colloid, papillae absent or rare, classic nuclear features of papillary carcinoma are seen.

Macrofollicular variant

Resembles adenomatoid nodules or hyperplastic nodules, large/macrofollicles with increased cellularity accentuated at the periphery colloid is scalloped or vacuolated. Abortive, rigid, straight papillary structures extend into the center of the follicle lined by atypical cells.

Oncocytic variant

> 70% papillary architecture. Enlarged cells with abundant oncocytic cytoplasm, apically oriented enlarged nuclei, increased intranuclear, cytoplasmic inclusions.

Clear cell variant

Clear cytoplasm, oncocytic and clear cells combined.

Diffuse sclerosing variant

Diffuse, bilateral involvement, extensive fibrosis, innumerable psammoma bodies, extensive intravascular growth and extrathyroidal extension, florid squamous metaplasia, dense lymphocytic thyroiditis, solid or papillary growth of papillary carcinoma cells.

Tall cell variant

> 70% of tumour composed of cells 3 times tall, oncocytic cytoplasm increased intranuclear cytoplasmic inclusions, centrally placed nuclei within cell.

Columnar cell variant

Prominent papillary growth, parallel follicles (railroad tracks) scant colloid, syncytial architecture with prominent nuclear stratification. Coarse nuclear chromatin, subnuclear cytoplasmic vacuolization, squamous metaplasia as morules and increased mitotic figures.

Solid / Insular variant

Solid or insular pattern with nuclear features of papillary carcinoma.

Micro carcinoma

Incidentally found < 1 cm, papillary carcinoma with a proclivity for thyroid subcapsular location.

Ultrasound imaging of metastatic lymph nodes

Size of the lymph node plays little role in the evaluation of malignancy. Since neoplastic infiltration of a lymph node begins in the cortex, malignant nodes have a larger transverse diameter and a rounder shape with an S : L of 0.5 or higher. A round shape is suggestive of malignancy, but its specificity may depend on the region of the neck. Peripheral neoplastic infiltration results

in loss of the hypoechoic cortex and may be replaced by a hyperechoic appearance. The node later becomes heterogenous and there may be intranodal calcifications cystic necrosis is also common and the echogenic hilus is lost.

Jugular compression or displacement of the jugular vein from the carotid artery suggests malignancy.

Colour or power Doppler examination shows that the vascular pattern is either peripheral or diffuse (hilar and peripheral) often with irregular distribution. The increase in peripheral nodal vascularity occurs because of initial deposition of the malignant cells in the marginal sinuses and the tumour induced angiogenesis causes subsequent neovascularisation. As infiltration proceeds, increased vascularity is apparent throughout the lymph node.

In medullary carcinoma, the nodes are hypoechoic, rounded with a central coarse calcification. In lymphoma the nodes have a characteristic fish flesh appearance with uniform hypoechogenicity and loss of fatty hilum.

Imaging surveillance of Thyroid cancer[22]

After the initial treatment, patients must be monitored regularly for recurrent disease utilizing clinical examination thyroglobulin measurement and sonological imaging.

The normal post thyroidectomy bed site appears as an inverted triangle of heterogenous echogenic tissue reflecting the proliferation of fibrofatty tissues within the operative bed. This triangle is bounded anteriorly by the overlying strap muscles, medially by the trachea and laterally by the carotid

and internal jugular vessels. Post operative edema, seromas and hematomas can distort the tissue planes in the immediate postoperative period. Before radio iodine ablation, the tissue in the thyroid bed appears as vascular lobules equal in echogenicity to the thyroid gland. Following ablation, the tissue appears as hypoechoic heterogenous nodules without internal vascularity.

Thyroidectomy bed recurrence typically appears as well defined hypoechoic oval nodules within the resection bed. A small proportion of recurrent nodules may contain microcalcifications.

As the sonographic features of recurrence are non-specific, a number of conditions may be mistaken for a recurrence. Suture bed granuloma may be present for years after surgery and one specific sonographic sign that can suggest this diagnosis is that presence of central linear echogenic lines within a hypoechoic nodule double parallel lines greater than 1 mm in width are particularly characteristic.

Other features which can be mistaken for recurrence are remnant thyroid, fibrosis, suture granuloma, strap muscles, reactive lymph nodes and fat necrosis.

Gray-scale sonographic features of metastasis include microcalcifications, cystic change, round shape, hyperechogenicity absence of a fatty hilum and an increased short axis diameter.

REVIEW OF LITERATURE

The ultrasound features of thyroid nodules that should be analysed are summarized in the consensus statement on thyroid nodules from the Society of Radiologists in Ultrasound (SRU)[14] and The American Association of Clinical Endocrinologists (AACE)[16].

Table 2 : Sonographic features of malignancy and benignancy in the thyroid nodule (from Solbiati et al[54].)

Feature	Benign	Malignant
Internal contents		
Purely cystic contents	++++	-
Cystic with thin septa	++++	+
Mixed solid and cystic	+++	++
Comet-tail artefact	++++	+
Echogenicity		
Hyperchoic	++++	+
Isoechoic	+++	++
Hypoechoic	++	+++
Halo		
Thin regular halo	++++	++
Thick regular halo	++	+++
Margins		
Well defined	+++	++
Poorly defined	+	+++
Calcifications		
Eggshell calcifications	++++	+
Coarse calcifications	+++	+
Microcalcifications	+	++++
Doppler		
Peripheral flow pattern	+++	+
Internal flow pattern	++	+++

+, rare probability (<1%); ++, low probability (<15%); +++, intermediate probability (16-84%); ++++, high probability (> 85%).

Tae et al classified thyroid nodules into three categories based on their having one or more of four features: nodules with microcalcifications, irregular or microlobulated margin, marked hypoechogeneicity and a shape that is taller than it is wide is classified as malignant. Nodules with the absence of all these are benign. Anechogenic cystic nodules are category 1. The sensitivity and specificity, PPV and NPV were 87%, 87%, 48% and 98% respectively.

66% of papillary thyroid cancers have at least one sonographic feature that is not typically associated with malignancy and 69% of benign nodules have one sonographic predictor of malignancy. Table 2 shows the significant overlap between the various features in benign and malignant lesion.[54]

Echogenicity may appear to be a robust observation, the interobserver reproducibility is only moderate[62] 20-30% of papillary carcinomas can be cystic. Halos may be found in 30% of papillary carcinomas but they are incomplete and, in about 87% of follicular carcinomas. 20-30% of papillary carcinomas can be cystic. Microcalcifications can be present in 7-14% of benign lesions.[23] Coarse calcifications can be seen in both benign and malignant lesions and are associated with malignancy when they appear with microcalcifications or in the center of a hypoechoic nodule. Egg shell calcifications are usually present in benign lesions, but rarely can be associated with malignant lesions. Table 3 compares the sensitivity, specificity positive predictive values and negative predictive values of each of these sonographic criteria from 6 large studies.

Table 3 : Comparison of sonographic criteria from 6 studies

Study	Number of Nodules	Clinical	Hypoecho-genicity (%)				Shape Spherical/ Tailer Than Wide (%)				Spiculated Margins (%)				Microcalcifications (%)			
			Sensitivity	Specificity	PPV	NPV	Sensitivity	Specificity	PPV	NPV	Sensitivity	Specificity	PPV	NPV	Sensitivity	Specificity	PPV	NPV
Takashima et al	259	P & NonP	83	49	40	89	-	-	-	-	72	63	44	85	36	93	70	78
Kim et al	155	NonP	26.5	94.3	68.4	73.5	32.7	92.5	66.7	74.8	55.1	83	60	85	36	83	60	80
Papini et al	402	NonP	87.1	43.4	11.4	-	-	-	-	-	77.5	85	30	80	55.1			
Nam-Goong et al	317	NonP	68.2	52.9	27	-	-	-	-	-	-	-	-	-	36.4	85.5	39	-
Capelli et al	701	NonP	79.1	53.3	15.1	96	83.6	81.5	32.4	97.9	47.8	74.3	16.4	93	73.1	69.2	20	96
Moon et al	849	P & NonP	87.2	58.5	60.7	86.1	40	91.4	77.4	67.4	48.3	91.8	81.3	70.7	44.2	90.8	77.9	68.8

Abbreviations : NonP, nonpalpable; NPV, negative predictive value; P. Palpable; PPV, positive predictive value

a Marked hypoechogenicity

b Clustered blurred and speculated margins together

As shown in Table, individual sonographic signs are only moderately sensitive and specific for predicting malignancy in solid thyroid nodules, there can be a significant overlap with benign processes, because almost 70% of histologically proved benign nodules may exhibit 1 suspicious sonographic sign.[62] However malignant nodules tend to harbor multiple suspicious findings, a mean of 2.6 abnormalities.[26] The only single sonographic feature that is considered to be safely benign is a purely cystic nodule. However combining features into a pattern may be helpful when triaging nodules. There are five patterns that have been shown to have high specificity for benignity.[5]

Likely benign patterns

1. Cystic nodules with or without internal Echogenic foci

Nodules that are small, less than 10 mm, fluid filled and solitary or multiple are benign. These are colloid filled cysts and exhibit a echogenic focus with a posterior reverberation known as comet tail or ring down artifact. Bonavita and colleagues have read these nodules pathologically as benign colloid nodules.[5]

2. Honey comb or spongiform pattern

This has innumerable tiny cystic spaces separated by thin bands or septations. It is usually avascular and occasionally vascularity can be identified. Echogenic foci if present are linear and are associated with the back wall of the tiny cysts, and thus are distinguished from microcalcifications in malignant nodules. Ginat[17] has shown that honey comb morphology has 100% specificity for benign nodular hyperplasia.

3. Large predominantly cystic nodules

The large amount of fluid may be secondary to degeneration, colloid or sequelae of haemorhage and only benign nodules demonstrate so much of cystic change. It is rare to find a malignant lesion which is more than 50% cystic.[19] But this can be applied only to nodules in the thyroid and nodal metastasis are often cystic.

4. Innumerable tiny nodules

Multiple tiny hypoechoic nodules separated by coarse echogenic bands has a 95% positive predictive value for Hashimoto's thyroiditis.[65] About 16% of nodules larger than the background nodularity are malignant and so discrete larger nodules should be evaluated for malignancy.

5. Markedly hyperechoic

It is 100% specific for a benign nodule[5]. This is a colloid type nodule or focal nodular Hashimoto's thyroiditis.

Worrisome Pattern

1. Solid hypoechoic nodules with discrete echogenic foci

This has a high probability for papillary thyroid carcinoma. However hypoechogenicity by itself may be seen in several benign nodules, but hypoechogenicity with microcalcifications has a higher specificity.

2. Solid hypoechoic nodules with coarse echogenic foci

This may be either a papillary or medullary carcinoma. Coarse calcifications may be due to aggregation of psammoma bodies or due to fibrosis of amyloid deposits seen in medullary carcinoma or due to dystrophic calcification in a benign nodule. However a combination of coarse central calcifications with hypoechogenicity is worrisome.

3. Solid homogenous egg shaped nodules with a thin capsule

These lesions may be isoechoic, hyperechoic or hypoechoic. Both benign and malignant lesions have this appearance. Sillery et al[53] found that hypoechogenicity, lack of cystic change or halo and a larger size favour malignant follicular carcinoma.

4. Refractive shadow from the edge of a solid lesion

This occurs at the junction of two tissues with differing sound propagation velocities at an oblique angle to the sound wave and is due to dense fibrous tissue at the periphery of a papillary carcinoma.[44]

Based on a combination of nodule characteristics the American Thyroid Association (ATA)[59] and the Society of Radiologists in Ultrasound (SRU) have published guidelines for nodule FNAC.

Criteria for FNAC

Size of Nodule (mm)	ATA	SRU
5 – 10	FNA if risk factors and suspicious sonographic features	No recommendation
10 – 15	FNAC if microcalcifications or is solid	FNA if microcalcifications present
15 – 20	Microcalcifications, is solid, or is both solid and cystic with suspicious features	FNA if microcalcifications or is solid with coarse calcifications
> 20	FNA of all solid nodules	Substantial growth cystic with mural nodules

The FNAC results of such lesions were prospectively correlated with the defined ultrasound patterns and a TIRADS **(The Thyroid Imaging Reporting and Data System)** group classification was generated[21]. The following categories were established.

TIRADS

1. Normal thyroid gland
2. Benign conditions (0% malignancy)
3. Probably benign nodules (5% malignancy)
4. Suspicious nodules (5-80% malignancy)
5. Probably malignant
6. Definitely malignant, proved by FNAC

The sensitivity, specificity, PPV, NPV and accuracy were 88, 49, 49, 88 and 94% respectively for the TIRADS system.

Lymph node imaging

Ultrasound is a superior adjunct in the evaluation of cervical lymph node metastases. CT and MRI provide information regarding the size of the suspicious node, but size itself is an unreliable criterion for malignancy.

Identification of metastatic adenopathy is the principle goal of lymph node sonographic imaging. Preoperative assessment of cervical lymph nodes is important in staging and will often determine optimal treatment approaches to cancers in the head and neck. The presence of adenopathy in the head and neck can be the result of underlying inflammation in upto 50% of cases. Conversely 20 to 40% of normal size nodes may harbor metastasis.[11]

Although large size is more commonly associated with malignancy, 33% to 71% of nodal metastates were found to have a maximum transverse diameter less than 1 cm.[60]

A long/short axis ratio of greater than 2.0 is predictive of inflammatory disease in 84% whereas a ratio less than 1.5 indicates metastatic disease in 71%[55]. This has a sensitivity of 81% to 95% and specificity of 67% to 96% in determining metastatic involvement of the lymph node. Furthermore the cut of L/S values for different cervical lymph node stations have been calculated. Submental-2 submandibular-1.4, parotid-2.0, upper cervical-2.5, middle cervical-3.3 and posterior triangle-2.5.[66]

Echogenicity of the node is a weak parameter in predicting malignancy 11% of reactive nodes can be heterogenous, 38% of metastatic nodes can be

homogenous[35]. If the cortex is less than one half of the transverse diameter, the probability of malignancy is < 9% whereas eccentric cortical thickening is suggestive of nodal metastasis.[61]

Nodal margin may not be a indicator of the pathology, as Moritz et al[41] noted that 46% of metastases had well defined margins and 14% of inflammatory nodes had ill-defined margins. The value of Doppler in this regard remains to be evaluated.

Multivariate analysis suggests that the criteria most predictive of metastatic cervical lymph node are absent hilar echoes and increase in short axis length.

Cervical ultrasound is the mainstay of DTC surveillance imaging and has replaced I^{131} WBS as the primary imaging modality. WBS has a sensitivity of 20% for the detection of local recurrence versus 70% for cervical ultrasound.[69]

FNAC of thyroid

It is a minimally invasive relatively painless, cheap and speedy diagnostic modality, established as the first line diagnostic test by a large body of world literature.

The following table evaluates the utility of this preoperative diagnostic tool.

Table 4 : Diagnostic yield of thyroid fine-needle aspiration

Series	No. of Cases	False-Negative Rate (%)	False-Positive Rate (%)	Sensitivity (%)	Specificity (%)
Hawkins, et al.	1,399	2.4	4.6	86	95
Khafagi, et al.	618	4.1	7.7	87	72
Hall, et al.	795	1.3	3.0	84	90
Altavilla, et al.	2,433	6.0	0.0	71	100
Gharib, et al.	10,971	2.0	0.7	98	99
Ravertto, et al.	2,014	11.2	0.7	89	99

These studies implicate that though FNAC has good sensitivity and specificity, it still has a false negative rate and so cases managed conservatively based on benign cytology have to be followed up closely.

Table 5 : Correlation of TIRADS category and risk of malignancy in FNAC

FNAC (n = 1097)	TIRADS 2 (n = 62)	TIRADS 3 (n = 326)	TIRADS 4 (n = 642)	TIRADS 5 (n = 67)
Benign	62%	280 (85.9%)	353 (55%)	7 (10.4%)
Follicular lesion	0%	35 (10.7%)	199 (31%)	2 (3.1%)
Cancer	0%	11 (3.4%)	90 (14%)	58 (86.5%)

This shows that ultrasound can be used to triage nodules and subject the high risk nodules to FNAC saving cost for the patient.

Aim of the Study

To evaluate the relevance of ultrasound in the diagnosis and surveillance of malignancy of the thyroid.

Objective

To identify a group of patients in whom the nodule is malignant and would benefit from early aggressive treatment while avoiding unnecessary investigation and surgery of patients with a benign nodule.

Period of Study

March 2010 – January 2012.

Place of Study

Department of Endocrine Surgery, Department of Radiology and Pathology, Madras Medical College and Rajiv Gandhi, Govt. General Hospital, Chennai.

Study Design

Prospective, cohort study.

Study Material

All patients with goiter attending the OPD of Endocrine Surgery Department in Government General Hospital, Chennai.

Inclusion Criteria

Patients with goiter attending the OP Department of Endocrine Surgery who give informed consent for the study.

Exclusion Criteria

Patients who did not undergo surgery / who were not willing for surgery were excluded from the study.

No. of Cases

350 cases who underwent total thyroidectomy were taken for anlaysis.

Method of Study

These patients were evaluated clinically and a baseline thyroid function tests was obtained. Ultrasound of the neck was performed by radiology residents on a rotation using Siemens Acuson Antares Premium model with a 7.5 to 15 MHz linear array transducer probe in the Department of Radiology. In euthyroid patients FNAC of the thyroid was performed by pathology residents in the Department of Cytology, using the non-aspiration technique with a 23 mm gauge needle. Slides were fixed in isopropyl alcohol and H&E staining was done. Slides were reported based on the Bethesda system of cytopathology.

Inconclusive and unsatisfactory smears were repeated under ultrasound guidance.

Ultrasound of the neck was performed by a single surgical resident at the time of admission, blinded for the sonographic and FNAC report, using a DUS 3 Digital Ultrasonic Diagnostic Imaging System with a multifrequency 5-15 MHz linear array transducer probe.

Thyroid ultrasound was performed with the patient in a supine position and with a pillow placed between the shoulders to allow hyperextension of the neck. Images were obtained in the transverse and longitudinal planes. The lobes of the thyroid and focal lesions were measured in three dimensions. Intrathoracic extension if thyroid disease were demonstrated by angling the ultrasound transducer into the mediastinum from a supra-manubrial position with additional maneuver such as swallowing. For imaging large goiters with increased antero-posterior diameter, the frequency of the probe was reduced from 7.5 MHZ to 5 MHz.

The following parameters were noted during the time of sonographic examination.

1. The echotexture of the lobes
2. presence of nodularity
3. the number of nodules (single, multiple)
4. the echogenicity of the nodules
5. the location of nodules (unilobar/bilobar)
6. the presence of halo
7. the regularity of the margins, presence of calcifications – micro, coarse and egg shell.

Doppler was not performed and so Doppler findings were not included for analysis.

For imaging the cervical lymph nodes, the transducer was placed on the mandibular gland in a horizontal orientation and moved inferiorly along the external carotid artery to the bifurcation of the common carotid artery. It was then centered over the jugulocarotid sheath and moved inferiorly till the carotid was visualized joining the subclavian artery on the right or disappeared under the clavicles to enter the arch on the left. The supraclavicular fossa and posterior triangle of the neck then examined by moving the probe laterally along the supraclavicular region and then posteriorly and superiorly to the mastoid region along the posterior edge of the sternocleidomastoid.

For imaging the central neck, the transducer was placed in the transverse orientation above the tracheal cartilage at the approximate level of the hyoid bone and moved inferiorly along the anterior border of the trachea to the sternal notch. The more focused examination of the left and right paratracheal regions required centering the probe between the trachea and respective carotid artery just inferior to the tracheal cartilage and scanning inferiorly to the sternal notch. Longitudinal imaging was performed for identified abnormal lymph node. Hard copy of the data was saved for future reevaluation.

Ultrasound classification for thyroid nodules

Based on the sonographic appearance, the following diagnosis were made.

Ultrasonographic features		**Diagnosis**
Round or oval anechoic lesion Regularly shaped nodule with cystic change with or without colloid nodule septations or coarse calcifications	-	Cyst (adenomatous/multi-nodular goiter) spongiform pattern.
Solid, hypoechoic, iso echoic or hyperechoic nodule with or without calcifications with a regular halo	-	Adenoma
Hypoechoic / Heteroechoic gland with or without nodules with or without calcifications Hypoechoic gland with small nodules with echogenic bands across both the lobes of the gland	-	Thyroiditis
Hypoechoic / Heteroechoic nodule with regular/irregular margins with fine/coarse calcifications	-	Pap Ca

For diagnosing nodal metastasis, Antonelli's criteria excluding size of the node – hypoechoic with loss of fatty hilum, heteroechoic irregular cystic appearance, rounded or bulging shape presence of internal calcification was used.

Imaging surveillance of post thyroidectomy cancer patients was done after 6 months following surgery and radioablation and once in 6 months thereafter, along with Thyroglobulin and antithyroglobulin antibody levels as

per the revised ATA thyroid cancer guidelines. Suspicious nodes, thyroid bed recurrences if detected were subjected to FNAC and reoperative procedures adopted if indicated.

The post surgical specimen was grossed, fixed in formalin. Paraffin embedded tissue was sliced to 2 cell thickness and stained with Haematoxylin and Eosin. Reporting was done as per the Department protocol. The slides were reviewed by a single pathologist and the final opinion was taken for analysis.

Statistical analysis

Data was analysed using a 17.0 SPSS software. The results of the SPUS was compared with that of the RPUS, FNAC and HPE by cross tabulation. Ranking of the variables was done using the Mann - Whitney non-parametric test and correlated by Kruskal Wallis and Spearman correlation test. Logistic regression multivariate analysis was done to compare nodule characteristics with malignancy.

Results

Ultrasonogram was performed for 389 patients. Cases managed conservatively and the post thyroidectomy PTC patients on surveillance, who did not have biochemical, radiological evidence of disease recurrence were eliminated from the study. The data of 350 patients was taken for analysis. There were 45 (12.9%) males and 305 (87.1%) female patients. The age group varied between 11 and 75 years. The mean age of presentation was 39.45 years.

The clinical profile of the study group comprised of

Multi nodular goiter	222
Solitary nodule	82
Diffuse toxic goiter	5
Toxic MNG	38
Recurrent goiter	3

Of the 350 patients, 93 patients were diagnosed to have malignancy by histopathology. In this there were 79 (84.9%) females and 14 (15.1%) males. The age distribution of the malignant population was 11-75 yrs and the mean age of presentation was 43.45 years. (Figure 4). 5 of them had vocal cord palsy preoperatively. The clinical profile of 93 patients was

Multi nodular goitre	53
Solitary nodule thyroid	32
Toxic MNG	3
Recurrence / Metastasis	5

The pathological profile of the patients included.

Papillary Ca	86
Medullary Ca	3
Metastatic Medullary Ca	2
Metastatic Pap Ca	2

The 86 cases included

Conventional type	36
Follicular variant	28
Micropapillary Ca	19
Anaplastic variant	1
Clear cell variant	1
Tall cell variant	1

It was multicentric in 21 cases. The variety of PTC in multicentric cases was

Conventional type in	13
Follicular variant in	8

The pathology associated with PTC in the opposite lobe was

Nodular colloid goiter	48
Thyroiditis	24
Normal	10
Nodular hyperplasia	4

SPUS, RPUS and FNAC were ranked with HPE. SPUS had the maximum rank with a P value of < 0.0001. The spearman correlation of all the three parameters is given in Table 6.

Table 6 : Correlation of SPUS, RPUS, FNAC against variable HPE

	Spearman Correlation	Std Error	Approx. TC	Significance
SPUS	0.886	0.028	35.652	.00001
RPUS	0.524	0.053	11.474	.00001
FNAC	0.405	0.052	8.258	.00001

Test statistics for the three parameters SPUS, RPUS and FNAC with grouping variable HPE by Kruskal Wallis test are tabulated in Table 7 (Page No.71).

The Spearman correlation for SPUS was 0.886 ($P < 0.0001$). There were 11 false positive cases of SPUS and 5 false negative cases.

The cross tabulation between SPUS findings and HPE are summarized in Table 8.

Table 8 : Comparison of SPUS findings with HPE

			Gross HPE		Total
			Benign	Malignant	
Gross SPUS	Benign	Count	246	5	251
		% within Gross SPUS	98.0%	2.0%	100.0%
	Malignant	Count	11	88	99
		% within Gross SPUS	11.1%	88.9%	100.0%
Total		Count	257	93	350
		% within Gross SPUS	73.4%	26.6%	100.0%

The sensitivity, specificity, positive predictive value, negative predictive value of SPUS are 98.53%, 95.72%, 96.81% and 98.00% respectively.

The Spearman correlation for RPUS against HPE was 0.524. There were 13 false positive cases and 47 false negative cases by RPUS. The cross tabulation of RPUS findings and pathologic diagnoses are given in Table 9.

Table 9 : Cross tabulation of RPUS against variable HPE

			Gross HPE		**Total**
			Benign	**Malignant**	
Gross RPUS	Benign	Count	244	47	291
		% within Gross RPUS	83.8%	16.2%	100.0%
	Malignant	Count	13	46	59
		% within Gross RPUS	22.0%	78.0%	100.0%
Total		Count	257	93	350
		% within Gross RPUS	73.4%	26.6%	100.0%

The sensitivity, specificity, positive predictive value, negative predictive value of RPUS are 86.05%, 94.94%, 95.19% and 83.8% respectively. Excluding the indeterminate, there were 57 false negatives and 10 false positives with FNAC. 1 case reported as indeterminate on FNAC turned out to be malignant on HPE. Correlation between FNAC and HPE is shown in Table 10.

Table 10 : Comparison of FNAC findings with HPE

	HPE		
FNAC	**Benign**	**Malignant**	**Total**
Benign	240	57	297
Malignant	10	35	45
Indeterminate	7	1	8
Total	257	93	350

The sensitivity, specificity, positive predictive value and negative predictive value for FNAC are 82.18%, 95.62%, 96.11% and 81.08% with the indeterminate group excluded from data.

The sensitivity and specificity of all three modalities - SPUS RPUS and FNAC are shown in Table 11.

Table 11 :Comparison of sensitivity and specificity of SPUS, RPUS, FNAC

	SPUS	**RPUS**	**FNAC**
Sensitivity	98.53%	86.05%	82.18%
Specificity	95.72%	94.94%	95.62%
Positive Predictive Value	96.81%	95.9%	96.11%
Negative Predictive Value	98.00%	83.8%	81.08%

The sensitivity and negative predictive value of SPUS is higher than RPUS & FNAC, while the specificity and positive predictive value are high for RPUS and FNAC showing that the surgeon tends to over diagnose malignancy.

The incidence of nodule characteristics – echogenicity, margins and calcifications is shown in Table 12.

Table 12 : Distribution of Nodule Characteristics in Benign and Malignant lesions

Variable	Benign	Malignant
Hypoechoic	113 (43.8%)	31 (33.7%)
Heteroechoic	40 (15.5%)	57 (62%)
Isoechoic	99 (38.4%)	4 (4.3%)
Hyperechoic	6 (2.3%)	0 (0%)
Regular margins	203 (78.7%)	29 (31.5%)
Irregular margins	15 (5.8%)	62 (67.4%)
Halo	37 (14.3%)	1 (1.1%)
Microcalcification	7 (2.7%)	63 (68.5%)
Coarse calcification	97 (37.6%)	54 (58.7%)
Eggshell calcification	3 (1.2%)	1 (1.1%)

It can be extrapolated from the table that only 6 patients had hyperechogenicity and all 6 were benign, therefore hyperechoic nodules seldom occur in malignancy.

This univariate analysis also shows that heteroechogenicity, irregular margins and microcalcifications were associated with an increased risk for DTC compared to hypo/isoechogenicity, regular margins coarse, egg shell and no calcifications.

Association was confirmed using a multivariate model, including the other SPUS characteristics, (Table 13, Page No.73).

Heteroechogenicity (OR – 3.782 95% CI – 1.012 – 14.13 P < 0.048) irregular margins (OR = 11.756 95% CI – 4.939 – 27.982 P < 0.000) and

microcalcifications (OR = 32.567, 95% CI – 12.094 – 87.693 P < 0.000) had a greater association with DTC after adjustment for the other characteristics.

On analyzing the characteristics of the nodes, heteroechoic nodes with calcifications proved to be malignant always while homogenously enlarged nodes with loss of fatty hilum turned out to be reactive.

Discussion

SPUS has become an important diagnostic modality for the evaluation of thyroid nodules by many endocrine surgeons. As an extension of the clinical examination of the neck, SPUS provides the unique opportunity to integrate real time ultrasound images with clinical presentation and the extensive knowledge of surgical neck anatomy that can be correlated later intra operatively. Moreover the surgeon sonographer can effectively monitor patients for persistent or recurrent thyroid cancer.

SPUS was more sensitive than RPUS and there was considerable variation between the two as shown by cross Table 14 Page No.72.

Pitfalls of Ultrasound

The increase in incidence of thyroid cancer is definitely because of improved diagnosis of even small nodules less than 5 mm, and this has been made possible because of the availability of high resolution ultrasound.

But small lesions may be displaced by the transducer with a direct scanning technique and may never actually be imaged. Use of very light

pressure on the neck while scanning to keep the mass under the transducer and immobilizing the mass if palpable with fingers may prevent this.

An anterior mass may be overlooked because of near field artifact and contact problems with high resolution ultrasound, thyroidal vessels – inferior thyroid artery and its branches can be mistaken for small cysts in the thyroid. Longitudinal scanning prevents this artifact.

A cystic component may occur in 13-26% of thyroid malignancies, but a predominant cystic component is still uncommon, but predominant cystic appearance may be mistaken for cystic change in a hyperplastic nodule.

A parathyroid cyst may be mistaken for a thyroid cyst.

A cystic metastatic node or an abnormal lymph node adjacent to the thyroid may be mistaken for a benign thyroid nodule, especially if they are calcified.

US characteristics of AITD especially Graves include enlargement of the thyroid with reduced echogenicity, heterogeneity and hypervascularity. Large nodular infiltrative malignancy may also have these features, and can be mistaken for AITD especially when associated with destructive thyroiditis or vice a versa.

Benign follicular adenomas can have a heteroechoic appearance with calcifications and can be mistaken for malignancy. Microcalcifications which are pathognomonic of papillary carcinoma can also be present in follicular adenomas and Hashimoto's thyroiditis and can be misinterpreted as

malignancy. Coarse calcifications can be present in longstanding malignancy and in benign degenerative disorders. Egg shell calcifications though predominantly seen in benign lesions can present in malignancy.

Although hypoechogenicity is an established parameter in detecting AITD, it has poor specificity in the morbidly obese, where hypoechogenicity was present in 64.8% of clinically and biochemically euthyroid patients with BMI > 40[48].

When diffuse thyroid abnormalities are present, detection of focal nodules particularly thyroid carcinoma is more difficult.[38] A solid hypo-echoic papillary carcinoma could be masked in a heterogenous thyroid gland containing pseudonodules from lymphocytic infiltrates and fibrosis. Though all types of calcification – fine, coarse and egg shell, can be seen in cases with coexistent hashimoto's, the frequency of psammoma bodies is lower, whereas the presence of dense calcifications is higher in patients with Hashimoto's when compared with a malignancy in a normal thyroid.

Not only can the parenchymal heterogenicity of Hashimoto's leads to false negative studies, false positive results can also occur when a nodule is perceived within surrounding heterogenous parenchyma.

Thus it becomes evident that single sonological feature correlates poorly with malignancy and a constellation of features is a better predictor, especially when performed by a clinician – surgeon who evaluates the nodule not only sonologically, but also clinically. However pattern analysis only points to the possibility of malignancy, but does not give tissue proof unlike FNAC.

The wide variations in the sonographic findings between the radiologist and surgeon could be because of overlap of sonographic features. Even among experienced ultrasonographers concordance of USG characteristics is far from 100%.[63] So it is expected that similar if not greater discrepancies would exist between the interpretations of the surgeon and radiologist.

Armed with full understanding of pathophysiology the surgeon can more aptly make decisions regarding which lesions are suspicious.

While imaging the lymph nodes the fatty hilum may not be conspicuous in benign reactive nodes when small and homogenous nodes without the hilar shadow may be reported as malignant nodes. Similarly the heteroechogenicity and peripheral shift of the fatty hilum may not be evident in small malignant nodes in the early stage of infiltration and may be interpreted as benign.

Heteroechogenicity irregular borders and microcalcifications had a greater association with DTC after adjustment for the other characteristics. Comparing the nodule characteristics of the present study with the study of Jabiev et al[3]., hypoechogenicity had a significant correlation in the other study while heteroechogenecity was significant in the present study. The table compares the nodule characteristics of both the studies.

Table 15 : Comparison between multivariate analysis of the nodule characteristics of the present study with other SPUS

SPUS characteristics		OR	95% CI	P Value
Present study	Hypochogenecity	3.100	0.93 – 10.3	0.065
	Heteroechogenecity	3.782	1.01 – 14.13	0.048
Irregular margins		11.756	4.94 – 27.98	0.000
Microcalcifications		32.567	12.09 – 87.07	0.000
Jabiev et al.				
Hypochogenecity		3.83	1.61 – 9.09	0.002
Irregular margins		2.9	1.2 – 6.98	0.018
Microcalcifications		2.74	1.1 – 6.87	0.031
Domniquez et al.				
Hypoechogenecity		4.7	2.8 – 8	0.04
Irregular margins		4.3	2.8 – 6.5	0.02
Microcalcifications		6.6	4.4 – 9.9	0.01

In case of indeterminate cytology, the surgeon can choose to operate if these ultrasound characteristics – Heteroechogenecity, Irregular margins and Microcalcifications are present.

Pitfalls of cytology

FNA of thyroid has become an important tool in evaluating thyroid nodules and the definitively positive and negative diagnoses have high sensitivity and specificity. Though FNAC gives a preoperative diagnosis of thyroid cancer it has a high false negative rate especially if the nodule is greater than 4 cm. From the cytopathologic perspective, most thyroid cancers are low grade and have pathologic features that overlap with other benign hyperplastic

or neoplastic nodules. These characteristics combined with the technical challenges associated with procuring an adequate thyroid sample highlight the difficulties in diagnostic thyroid cytology. Comparison of FNAC and HPE Findings are shown in Table 16 (Page No.75).

In benign lesions, cytologic[73] misclassification does not harm the patients. Thyroiditis can be reported as colloid goiter and suspected neoplasm and adenomatoid nodules can prove to be thyroiditis, because Hurthle cells can be derived from a variety of lesions, commonly nodular goiter, chronic lymphocytic thyroiditis and follicular neoplasm of Hurthle cell type.

In malignancy, the negative predictive value of a screening test should be ideally 100%. In reality this is not possible.

The commonly cited Pitfalls are,

Cytology does not pick up capsular or vascular invasion. Hence follicular carcinomas cannot be distinguished from adenomas. The same is true with Hurthle cell adenoma and carcinoma. Artifactual bubbling in normal nuclei may be confused with intranuclear holes in papillary carcinoma. Non neoplastic atypia in Hashimoto's thyroiditis, post irradiation thyroiditis and dyshormonogenic goiter can be mistaken for malignancy.

In multinodular goiter, the exact location of the malignant process can be missed by the needle and thus result in a false negative state.

The cystic degenerations in a poorly differentiated carcinoma may be misclassified as a benign lesion and so might account for false negative smears.

The polymorphous lymphocytes and epithelial cells in a low grade lymphoma and a well differentiated papillary carcinoma arising in the background of thyroiditis can be reported as lymphocytic thyroiditis.[39]

Graves disease shows large sheets of hyperplastic cells with abundant cytoplasm. Oncocytes and lymphocytes may be present in the background. But it should characteristically lack nuclear atypia and microfollicular component. But this can also be seen in a follicular adenoma, follicular carcinoma and follicular variant of papillary carcinoma. Yet another false negative rate can be seen with follicular variant of papillary carcinoma where the subtle nuclear changes may not be detected on cytology and the lack of papillae may be difficult to distinguish from follicular neoplasms. Wide inter observer variations involve the follicular variant of papillary carcinoma and oncocytic variant of papillary carcinoma.

Thus the reasons for the wide variations in reporting malignancy can be multifactorial and can be due to patient and regional characteristics, operator and processing techniques, surgical pathology analysis and diagnostic threshold.

By combining clinical, ultrasonographic immunohistochemical markers, it is possible to overcome the pitfalls of FNAC.

Pitfalls of Histopathology

Compared with radiologist performed ultrasound and FNAC, surgeon performed ultrasound findings correlated with HPE report.

However 11 cases reported as malignant on SPUS turned out to be benign on HPE (false positive) and 5 cases reported as benign turned out to be malignant (false negative). Table 17 shows the comparative diagnosis in false positive cases and table 18 shows the comparative diagnoses in false negative cases. Cross tabulation between SPUS vs HPE, Table 19, Page No.76.

Table 17 : Cases malignant on SPUS, benign on HPE (False positive)

S.No.	SPUS	RPUS	FNAC	HPE
1.	Pap Ca	Colloid	Colloid	OAH
2.	Pap Ca	Colloid	Colloid	OAH
3.	Pap Ca	Colloid	Colloid	Papillary hyperplasia
4.	Pap Ca	MNG	Papillary hyperplasia	Papillary hyperplasia
5.	Pap Ca	MNG	Colloid	Papillary hyperplasia
6.	Pap Ca	SNT	Colloid	Papillary hyperplasia
7.	Pap Ca	Colloid	Colloid	Papillary hyperplasia
8.	Pap Ca	Pap Ca	Pap Ca	Papillary hyperplasia
9.	Pap Ca	Colloid	Colloid	Papillary hyperplasia
10.	Pap Ca Mets	Pap Ca Mets	Pap Ca Mets	Reactive nodes
11.	Pap Ca	MNG	Colloid	Adenoma

Table 18 : Cases benign on SPUS, malignant on HPE (False negative)

S.No.	SPUS	RPUS	FNAC	HPE
1.	Colloid	Colloid	NCG	Pap Ca
2.	Thyroiditis	MNG	Thyroiditis	Pap Ca (F.V)
3.	Thyroiditis	Pap Ca	Colloid	Pap Ca
4.	Colloid	MNG	Colloid	Pap Ca (F.V)
5.	Colloid	Pap Ca	Colloid	Pap Ca (F.V)

A variety of thyroid lesions can exhibit papillae and the differential diagnosis includes nodular goiter, follicular adenoma with papillary hyperplasia, toxic follicular adenoma Hurthle cell adenoma carcinoma with papillae, medullary carcinoma – papillary variant, Hashimoto's thyroiditis.

The papillae encountered in benign lesions are usually broad and contain follicles in the cores. Delicately branching papillae can occasionally be present. But the nuclei are regular, non-crowded, basally situated, dark, round nuclei resembling "beads on a string," in contrast to haphazardly oriented pale nuclei of papillary carcinoma.[46]

Fibrovascular core may be seen in thyroiditis and toxic follicular adenoma. The typical nuclear features of papillary carcinoma are lacking, though nuclear clearing – a preparation artifact may be seen; more in Hashimoto's thyroiditis, calcified colloid mimicking psammoma bodies may be seen. Occasional nuclear grooves can be present in Hurthle cell adenoma.

The diagnosis given by SPUS in the five false negative cases were, thyroiditis, in 2 patient colloid goiter in 3 patients.

All five cases showed papillary projections with occasional nuclear clearing, but nuclear crowding a characteristic feature of papillary carcinoma was absent. One case, a case of recurrent toxic MNG, showed scalloping of colloid apart from the papillary projections.

The differential diagnosis of encapsulated cellular follicular patterned lesion includes adenomatoid / hyperplastic nodule, follicular and Hurthle cell adenoma, follicular and Hurthle cell carcinoma, follicular variant of papillary carcinoma and follicular variant of medullary carcinoma.

The distinction between follicular carcinoma and follicular adenoma rests on identification of vascular or capsular invasion. Clinically there are instances where cases undergoing hemithyroidectomy for follicular adenoma later present with distant metastases. This could be due to the fact that sections did not include the site of vascular or capsular invasion. Is it really worthwhile to include more sections in search of capsular invasion in a slow growing tumour has been debated for long.

Morphologic criteria for the distinction between adenomatoid nodule and follicular adenoma are not well defined. Nonetheless it does not matter whether the nodule is labelled one way or the other.

The most difficult diagnostic problem is when there are some pale or clear nuclei for which the differential diagnosis is between follicular variant of papillary carcinoma and follicular adenoma. This is because some papillary carcinomas may not exhibit all the characteristic nuclear features while some follicular adenomas can exhibit focal clear or grooved nuclei.

The reproducibility in the diagnosis of encapsulated follicular lesions that show focal and or incompletely developed nuclear features of papillary carcinoma is very low.[12] The follicular variant must show typical nuclear features of papillary carcinoma. If clear nuclei are confined to the central portion of the tumour but are absent in the peripheral portion, the most likely explanation is a follicular adenoma or adenomatoid nodule with delayed fixation, resulting in artifactual blowing up and clearing of the nuclei.

The differential diagnoses of cells rich in oncocytes includes Hurthle cell adenoma/carcinoma, oncocytic variant of PTC and medullary carcinoma, oncocytic nodules in Hashimoto's thyroiditis, adenomatoid nodule with oncocytic cells. Distinction between oncocytic variant of PTC and Hurthle cell adenoma/carcinoma is problematic. The oncocytic variant of PTC may lack papillae and nuclear crowding may not be evident as a result of the abundance of cytoplasm. On the other hand, in Hurthle cell adenoma/carcinoma some nuclei may show grooving or even rare intranuclear inclusions and the calcified colloid may mimic psammoma bodies.[2]

Thus it becomes evident that though histopathology is the gold standard in the diagnosis of tumours, it has its own grayzones and areas of overlap where a pathologist overdiagnoses malignancy using lax criteria to avoid being sued for missing a malignancy and another pathologist adopts a conservative policy because the prognosis of some of the variants is so good and no harm is done even if it is underdiagnosed as benign.

Conclusion

Ultrasound has definitely revolutionsed the management of thyroid nodules. When a surgeon performs it, he gains more real time information and this information has altered the management plan. Even microcarcinomas with false negative FNAC have been identified by SPUS.

SPUS had a higher spearman correlation and Kruskal Wallis score when tested against HPE, along with RPUS and FNAC. The sensitivity, specificity, positive predictive value and negative predictive value of the three modalities is shown below in the Table.

	SPUS	**RPUS**	**FNAC**
Sensitivity	98.53%	86.05%	82.18%
Specificity	95.72%	94.94%	95.62%
Positive Predictive Value	96.81%	95.9%	96.11%
Negative Predictive Value	98.00%	83.8%	81.08%

When nodule characteristics were correlated with malignancy by a multivariate analysis, heteroechogenicity, (OR – 3.782, CI – 1.012 – 14.13 $P < 0.048$) irregular margins (OR – 11.756 95% CI – 4.939 – 27.982, $P < 0.000$) and microcalcifications (OR – 32.567, 95% CI – 12.094 – 87.693, $P < 0.000$) had a greater association with DTC after adjustment for the other characteristics.

Hypoechogenicity had less significance in variation with other studies.

However there are overlapping features in all three diagnostic modalities – sonography, FNAC and histopathology especially in identifying the oncocytic and follicular variants of PTC. The surgeon scores over the radiologist as he is more familiar with the anatomy of the region, more focused on exclusively scanning the thyroid, and correlates the sonological findings with clinical features. Moreover, the surgeon sonographer can effectively monitor patients for persistent or recurrent thyroid cancer.

Complete tesslation between the surgeon and the pathologist is mandatory for the benefit of the patient, to overcome the overlap zones. It will be more apt if the pathologist visits the operating room when the surgeon briefs on the clinical evaluation of the patient and the pathologist gains first hand information by grossing the specimen before it is formalin fixed. The surgeon can visit the pathology suite to discuss, understand the diagnostic challenges and review the diagnosis with the pathologist before final reporting is done. This avoids the misinterpretation and misrepresentation of samples.

FNAC and ultrasound are useful clinical adjuncts which aid in the preoperative diagnosis of malignancy, and do not replace clinical judgement. Ultrasound points to the diagnosis of malignancy but does not give tissue proof.

FIGURE 4

AGE DISTRIBUTION OF MALIGNANT CASES

Table 7 : Ranks and Kruskal Wallis Test Scores of SPUS, RPUS, FNAC against variable HPE

Ranks			
	Gross HPE	**N**	**Mean Rank**
Gross SPUS	Benign	257	133.49
	Malignant	93	291.59
	Total	350	
Gross RPUS	Benign	257	154.85
	Malignant	93	232.56
	Total	350	
Gross FNAC	Benign	257	161.03
	Malignant	93	215.48
	Total	350	

Test Statistics[a,b]			
	Gross SPUS	**Gross RPUS**	**Gross FNAC**
Chi-Square	273.985	95.795	51.116
df	1	1	1
Asymp. Sig.	.000	.000	.000
a. Kruskal Wallis Test			
b. Grouping Variable: Gross HPE			

Table 14 : SPUS * RPUS Crosstabulation

			rpus									Total
			pap ca	**colloid**	**thyroiditis**	**Adenoma**	**pap ca mets**	**med ca**	**med ca mets**	**snt**	**mng**	
spus	pap ca	Count	38	23	0	2	0	0	0	7	20	90
		% within spus	42.2%	25.6%	.0%	2.2%	.0%	.0%	.0%	7.8%	22.2%	100.0%
	colloid	Count	10	82	2	4	0	0	0	10	19	127
		% within spus	7.9%	64.6%	1.6%	3.1%	.0%	.0%	.0%	7.9%	15.0%	100.0%
	thyroiditis	Count	1	21	51	1	0	0	0	2	17	93
		% within spus	1.1%	22.6%	54.8%	1.1%	.0%	.0%	.0%	2.2%	18.3%	100.0%
	adenoma	Count	2	8	0	5	0	0	0	7	9	31
		% within spus	6.5%	25.8%	.0%	16.1%	.0%	.0%	.0%	22.6%	29.0%	100.0%
	pap ca mets	Count	0	0	0	0	4	0	0	0	0	4
		% within spus	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	100.0%
	med ca	Count	0	0	1	0	0	2	0	0	0	3
		% within spus	.0%	.0%	33.3%	.0%	.0%	66.7%	.0%	.0%	.0%	100.0%
	med ca mets	Count	0	0	0	0	0	0	2	0	0	2
		% within spus	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	100.0%
Total		Count	51	134	54	12	4	2	2	26	65	350
		% within spus	14.6%	38.3%	15.4%	3.4%	1.1%	.6%	.6%	7.4%	18.6%	100.0%

Table 13 : Multivariate analysis of nodule characteristics

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	hypo(1)	19.602	15262.909	.000	1	.999	3.257E8	.000	.
	hetero(1)	19.801	15262.909	.000	1	.999	3.976E8	.000	.
	iso(1)	18.669	15262.909	.000	1	.999	1.282E8	.000	.
	reg(1)	.880	1.382	.406	1	.524	2.411	.161	36.191
	irreg(1)	3.195	1.398	5.223	1	.022	24.409	1.576	378.022
	halo(1)	-.583	1.793	.106	1	.745	.558	.017	18.729
	fine(1)	3.521	.518	46.186	1	.000	33.828	12.253	93.393
	coarse(1)	.147	.441	.111	1	.739	1.159	.488	2.750
	eggshell(1)	.893	1.589	.316	1	.574	2.442	.109	54.948
	Constant	-22.940	15262.909	.000	1	.999	.000		
Step 2[a]	hypo(1)	19.602	15277.783	.000	1	.999	3.257E8	.000	.
	hetero(1)	19.810	15277.783	.000	1	.999	4.012E8	.000	.
	iso(1)	18.658	15277.783	.000	1	.999	1.268E8	.000	.
	reg(1)	1.235	.893	1.914	1	.166	3.440	.598	19.792
	irreg(1)	3.547	.932	14.496	1	.000	34.713	5.591	215.527
	fine(1)	3.530	.517	46.569	1	.000	34.119	12.380	94.036
	coarse(1)	.131	.438	.089	1	.765	1.140	.483	2.691
	eggshell(1)	.887	1.590	.311	1	.577	2.428	.108	54.750
	Constant	-23.294	15277.783	.000	1	.999	.000		
Step 3[a]	hypo(1)	19.634	15229.710	.000	1	.999	3.364E8	.000	.
	hetero(1)	19.866	15229.710	.000	1	.999	4.244E8	.000	.
	iso(1)	18.661	15229.710	.000	1	.999	1.271E8	.000	.
	reg(1)	1.238	.893	1.922	1	.166	3.450	.599	19.866
	irreg(1)	3.582	.925	14.986	1	.000	35.935	5.861	220.336
	fine(1)	3.509	.512	46.985	1	.000	33.411	12.251	91.123
	eggshell(1)	.795	1.571	.256	1	.613	2.215	.102	48.144
	Constant	-23.268	15229.710	.000	1	.999	.000		

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 4[a]	hypo(1)	19.551	15151.254	.000	1	.999	3.096E8	.000	.
	hetero(1)	19.820	15151.254	.000	1	.999	4.052E8	.000	.
	iso(1)	18.592	15151.254	.000	1	.999	1.187E8	.000	.
	reg(1)	1.248	.893	1.953	1	.162	3.484	.605	20.069
	irreg(1)	3.600	.925	15.139	1	.000	36.601	5.969	224.418
	fine(1)	3.486	.509	46.852	1	.000	32.660	12.036	88.620
	Constant	-23.194	15151.254	.000	1	.999	.000		
Step 5[a]	hypo(1)	1.088	.620	3.083	1	.079	2.969	.881	10.003
	hetero(1)	1.362	.675	4.076	1	.043	3.905	1.041	14.655
	reg(1)	1.259	.897	1.971	1	.160	3.521	.607	20.415
	irreg(1)	3.563	.925	14.844	1	.000	35.264	5.757	216.015
	fine(1)	3.495	.509	47.082	1	.000	32.934	12.138	89.362
	Constant	-4.728	1.013	21.770	1	.000	.009		
Step 6[a]	hypo(1)	1.131	.613	3.406	1	.065	3.100	.932	10.307
	hetero(1)	1.330	.672	3.913	1	.048	3.782	1.012	14.129
	irreg(1)	2.464	.442	31.026	1	.000	11.756	4.939	27.982
	fine(1)	3.483	.505	47.503	1	.000	32.567	12.094	87.693
	Constant	-3.601	.546	43.437	1	.000	.027		

a. Variable(s) entered on step 1: hypo, hetero, iso, reg, irreg, halo, fine, coarse, eggshell.

Table 16 : FNAC * HPE Crosstabulation

			Hpe										
			pap ca	**colloid**	**thyroiditis**	**adenoma**	**pap ca mets**	**med ca**	**med ca mets**	**papillary hyperplasia**	**oncocytic adenomatoid hyperplasia**	**reactive nodes**	**Total**
fnac	pap ca	Count	28	5	2	1	0	0	0	1	0	0	37
		% within fnac	75.7%	13.5%	5.4%	2.7%	.0%	.0%	.0%	2.7%	.0%	.0%	100.0%
	colloid	Count	47	114	51	22	0	1	0	6	3	0	244
		% within fnac	19.3%	46.7%	20.9%	9.0%	.0%	.4%	.0%	2.5%	1.2%	.0%	100.0%
	thyroiditis	Count	7	3	34	2	0	0	0	0	0	0	46
		% within fnac	15.2%	6.5%	73.9%	4.3%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%
	adenoma	Count	1	0	0	1	0	0	0	0	0	0	2
		% within fnac	50.0%	.0%	.0%	50.0%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%
	pap ca mets	Count	0	0	0	0	3	0	0	0	0	1	4
		% within fnac	.0%	.0%	.0%	.0%	75.0%	.0%	.0%	.0%	.0%	25.0%	100.0%
	med ca	Count	0	0	0	0	0	2	0	0	0	0	2
		% within fnac	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	.0%	100.0%
	med ca mets	Count	0	0	0	0	0	0	2	0	0	0	2
		% within fnac	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	.0%	100.0%
	follicular neoplasm	Count	0	2	0	4	0	0	0	0	0	0	6
		% within fnac	.0%	33.3%	.0%	66.7%	.0%	.0%	.0%	.0%	.0%	.0%	100.0%
	papillary hyperplasia	Count	2	0	3	1	0	0	0	1	0	0	7
		% within fnac	28.6%	.0%	42.9%	14.3%	.0%	.0%	.0%	14.3%	.0%	.0%	100.0%
Total		Count	85	124	90	31	3	3	2	8	3	1	350
		% within fnac	24.3%	35.4%	25.7%	8.9%	.9%	.9%	.6%	2.3%	.9%	.3%	100.0%

Table 19 : HPE * SPUS Crosstabulation

			spus							Total
			pap ca	colloid	thyroiditis	Adenoma	pap ca mets	med ca	med ca mets	
hpe	pap ca	Count	80	4	1	0	0	0	0	85
		% within hpe	94.1%	4.7%	1.2%	.0%	.0%	.0%	.0%	100.0%
	colloid	Count	0	106	12	6	0	0	0	124
		% within hpe	.0%	85.5%	9.7%	4.8%	.0%	.0%	.0%	100.0%
	thyroiditis	Count	0	8	80	2	0	0	0	90
		% within hpe	.0%	8.9%	88.9%	2.2%	.0%	.0%	.0%	100.0%
	adenoma	Count	1	8	0	22	0	0	0	31
		% within hpe	3.2%	25.8%	.0%	71.0%	.0%	.0%	.0%	100.0%
	pap ca mets	Count	0	0	0	0	3	0	0	3
		% within hpe	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	100.0%
	med ca	Count	0	0	0	0	0	3	0	3
		% within hpe	.0%	.0%	.0%	.0%	.0%	100.0%	.0%	100.0%
	med ca mets	Count	0	0	0	0	0	0	2	2
		% within hpe	.0%	.0%	.0%	.0%	.0%	.0%	100.0%	100.0%
	papillary hyperplasia	Count	7	0	0	1	0	0	0	8
		% within hpe	87.5%	.0%	.0%	12.5%	.0%	.0%	.0%	100.0%
	oncocytic adenomatoid hyperplasia	Count	2	1	0	0	0	0	0	3
		% within hpe	66.7%	33.3%	.0%	.0%	.0%	.0%	.0%	100.0%
	reactive nodes	Count	0	0	0	0	1	0	0	1
		% within hpe	.0%	.0%	.0%	.0%	100.0%	.0%	.0%	100.0%
Total		Count	90	127	93	31	4	3	2	350

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MASTER CHART

S.No.	Name	Age	S	IP No.	SPUS	RPUS	FNAC	HPE	Echo Rt	Echo Lt	Nodule Rt	Nodule Lt	Calcifications	Nodes
1.	alamelu	55	f	54678	pap ca	pap ca	colloid	pap ca	hetero	iso	no	hetero irr	fine	lt mn
2.	sarala	35	f	54778	colloid	colloid	colloid	colloid	hetero	hetero	hypo reg	iso reg	coarse	no
3.	muniammal	30	f	54783	pap ca	pap ca	pap ca	pap ca	iso	hypo	iso reg	hetero irr	fine	no
4.	vanitha	23	f	52694	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	iso halo	no	no	no
5.	munishwari	37	f	53743	pap ca	pap ca	colloid	pap ca	iso	iso	hyper reg	hetero irr	fine coarse	no
6.	sivagami	32	f	52696	pap ca	pap ca	pap ca	pap ca	iso	iso	iso halo	hetero irr	fine	no
7.	sumathy	29	f	52752	colloid	colloid	colloid	colloid	iso	iso	no	cystic reg	no	no
8.	fathima	48	f	50487	colloid	colloid	colloid	colloid	hetero	hetero	hypo reg	iso reg	no	no
9.	jayaseeli	25	f	61137	colloid	colloid	colloid	colloid	iso	iso	hypo reg	iso reg	no	no
10.	subashini	29	f	56959	pap ca	snt	pap ca	pap ca	iso	hetero	no	hetero irr	fine coarse	lt bn
11.	kanniammal	40	f	56934	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	no	no	no	no
12.	andal	48	f	56986	colloid	pap ca	colloid	colloid	hetero	hetero	hypo reg	hypo reg	no	no
13.	alamelu	40	f	55849	colloid	pap ca	colloid	colloid	iso	iso	cystic reg	no	no	no
14.	subbulakshmi	20	f	56940	adenoma	pap ca	follicular neoplasm	adenoma	hypo	iso	iso halo	no	no	no
15.	jayakodi	50	f	55874	colloid	pap ca	colloid	colloid	iso	iso	cystic reg	cystic reg	no	no
16.	vijayalaxmi	55	f	55789	thyroiditis	colloid	colloid	colloid	hetero	hetero	iso reg	iso reg	coarse	no
17.	illayaraja	19	m	49470	adenoma	colloid	colloid	colloid	iso	iso	hyper halo	cystic reg	no	no
18.	anandababu	30	m	55928	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	hypo	cystic reg	cystic reg	coarse	no
19.	sathish	23	m	52731	colloid	mng	colloid	colloid	iso	iso	iso reg	iso reg	coarse	no
20.	sindhu	30	f	60241	colloid	colloid	colloid	colloid	iso	iso	hypo reg	iso reg	no	no
21.	maragatham	27	f	62407	colloid	colloid	colloid	colloid	iso	iso	cystic irr	iso reg	no	no
22.	kumari	24	f	59138	colloid	mng	colloid	colloid	iso	iso	no	no	no	no
23.	maria selvi	50	f	59137	colloid	colloid	colloid	colloid	absent	iso	no	hypo reg	coarse	lt bn
24.	jayashree	41	f	59528	colloid	mng	colloid	colloid	iso	iso	hyper reg	hyper reg	no	no
25.	rengammal	40	f	60276	colloid	colloid	papillary hyperplasia	thyroiditis	iso	iso	hypo reg	iso reg	coarse	no
26.	amsaveni	46	f	66779	colloid	adenoma	colloid	colloid	iso	iso	cystic reg	cystic reg	no	no
27.	amala	23	f	68713	adenoma	adenoma	colloid	colloid	iso	iso	no	iso halo	no	no

28.	rajeswari	65	f	64619	colloid	colloid	follicular neoplasm	colloid	iso	iso	cystic reg	hypo reg	coarse	no
29.	mari	35	f	60234	colloid	mng	colloid	colloid	iso	iso	hypo reg	hypo reg	no	no
30.	jaya	50	f	55874	colloid	mng	colloid	colloid	iso	iso	hyper reg	hyper reg	no	no
31.	annamayil	35	f	64654	thyroiditis	mng	colloid	thyroiditis	hypo	hypo	iso reg	iso reg	no	no
32.	thenmozhi	17	f	66715	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	iso reg	iso reg	no	no
33.	nithya	26	f	76475	colloid	colloid	colloid	thyroiditis	iso	iso	cystic reg	cystic reg	no	no
34.	emmanuel	14	m	55875	adenoma	snt	follicular neoplasm	adenoma	iso	iso	iso halo	no	no	no
35.	devaki	45	f	78934	colloid	colloid	colloid	colloid	iso	iso	cystic irr	no	coarse	no
36.	panjali	55	f	65845	thyroiditis	mng	thyroiditis	thyroiditis	iso	iso	hyper reg	hyper reg	no	no
37.	kasthuri	63	f	76418	colloid	colloid	colloid	colloid	iso	iso	cystic irr	cystic reg	coarse	no
38.	prema	45	f	76442	colloid	colloid	colloid	colloid	iso	iso	no	hetero reg	coarse	lt bn
39.	govindammal	45	f	76416	pap ca	mng	colloid	pap ca	iso	iso	no	hetero reg	fine	no
40.	mangayarkarasi	65	f	77670	pap ca	mng	colloid	pap ca	iso	iso	hetero irr	cystic reg	fine coarse	rt bn
41.	govindan	29	m	76543	colloid	colloid	colloid	colloid	iso	iso	iso halo	cystic reg	no	no
42.	sundari	35	f	78914	colloid	snt	pap ca	colloid	iso	iso	no	cystic reg	no	no
43.	girija	40	f	78919	med ca	thyroiditis	colloid	med ca	absent	iso	no	no	coarse	cmn
44.	padmavathi	75	f	73954	pap ca	pap ca	colloid	pap ca	iso	iso	hypo reg	hetero irr	fine	no
45.	vani	26	f	76403	pap ca	pap ca	pap ca	pap ca	iso	iso	hypo reg	hetero irr	fine	no
46.	malliga	42	f	73908	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	no	no	no	no
47.	manjula	36	f	80131	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	iso	hypo reg	no	no	no
48.	maheswari	28	f	83625	med ca	med ca	med ca	med ca	iso	iso	no	hetero irr	coarse	lt mn
49.	shailaja	27	f	83604	colloid	mng	colloid	colloid	iso	iso	no	cystic reg	coarse	no
50.	indumathy	39	f	83635	colloid	mng	colloid	colloid	iso	iso	hypo halo	iso reg	no	no
51.	kasthuri	48	f	80167	colloid	mng	colloid	colloid	iso	iso	no	hetero reg	coarse	no
52.	arjunan	70	m	70831	pap ca mets	pap ca mets	pap ca mets	pap ca mets	absent	absent	no	no	fine	rt mn
53.	raja	35	m	83607	colloid	thyroiditis	colloid	colloid	iso	iso	no	no	no	no
54.	babu	42	m	83641	colloid	colloid	colloid	colloid	iso	iso	hetero reg	no	no	no
55.	prem kumar	24	m	76435	thyroiditis	colloid	colloid	thyroiditis	hypo	hypo	iso reg	iso reg	no	bbn
56.	renu	48	f	83642	pap ca	pap ca	pap ca	pap ca	iso	iso	hetero irr	no	fine coarse	lt bn
57.	shobana	22	f	85777	colloid	snt	colloid	adenoma	iso	iso	iso reg	no	no	no
58.	amsa	40	f	85793	thyroiditis	colloid	colloid	thyroiditis	iso	hypo	no	no	no	no
59.	chinnakuppan	40	m	87004	pap ca	pap ca	pap ca	pap ca	iso	iso	hetero irr	hypo irr	fine coarse	rt mn lt

														bn
60.	kanchana	42	f	83676	colloid	thyroiditis	colloid	colloid	iso	iso	iso reg	cystic reg	no	no
61.	malliga	52	f	86951	colloid	snt	colloid	colloid	absent	iso	no	no	no	no
62.	kalaiselvi	35	f	88087	colloid	snt	colloid	colloid	iso	iso	iso reg	no	no	no
63.	manonmani	40	f	88108	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	hypo	no	iso reg	no	bbn
64.	muthulakshmi	47	f	86980	colloid	colloid	colloid	colloid	absent	iso	no	cystic irr	coarse	lt bn
65.	saritha	25	f	86954	thyroiditis	colloid	colloid	thyroiditis	hypo	hypo	no	no	no	bbn
66.	pushpalatha	44	f	93035	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	iso reg	iso reg	no	no
67.	kalaiselvi	35	f	92996	thyroiditis	mng	colloid	thyroiditis	iso	hypo	no	no	no	no
68.	vanitha	46	f	94128	thyroiditis	mng	colloid	colloid	iso	hypo	iso reg	iso	no	no
69.	kavitha	30	f	94057	colloid	colloid	colloid	colloid	absent	iso	no	no	no	no
70.	shanthi	29	f	92971	thyroiditis	colloid	colloid	thyroiditis	hypo	iso	no	no	no	no
71.	malliga	41	f	94079	pap ca	pap ca	colloid	pap ca	iso	iso	iso reg	hetero irr	fine	no
72.	manimegalai	62	f	93004	pap ca	colloid	colloid	pap ca	iso	iso	cystic irr	hetero irr	fine	no
73.	glory	51	f	97263	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	iso	iso reg	iso reg	no	no
74.	zeenath	33	f	97270	thyroiditis	thyroiditis	colloid	thyroiditis	hetero	hetero	no	no	no	no
75.	kantha	46	f	101362	thyroiditis	colloid	colloid	thyroiditis	iso	iso	no	iso halo	no	bbn
76.	boopathi	48	f	99394	colloid	colloid	colloid	colloid	iso	iso	iso reg	hypo reg	no	no
77.	fathimuthu	55	f	101362	thyroiditis	pap ca	colloid	thyroiditis	hetero	hetero	hypo reg	cystic reg	coarse	no
78.	pappammal	60	f	94662	pap ca	pap ca	pap ca	papca	iso	iso	hetero reg	hetero irr	fine coarse	lt mn
79.	gnanamani	55	f	98350	pap ca	mng	colloid	pap ca	iso	iso	iso reg	hypo irr	coarse	no
80.	anthony	36	f	99121	colloid	mng	colloid	colloid	iso	iso	iso reg	iso reg	no	no
81.	sangeetha	30	f	99414	pap ca	colloid	colloid	pap ca	iso	hypo	hypo irr	iso reg	coarse	rt mn lt bn
82.	arumugam	26	m	101373	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	iso	no	no	no	no
83.	kokila	27	f	101342	colloid	mng	colloid	colloid	iso	iso	iso reg	hypo reg	no	no
84.	navaneetham	37	f	102375	thyroiditis	thyroiditis	colloid	thyroiditis	iso	hetero	no	hetero reg	coarse	no
85.	rajeswari	55	f	103438	pap ca	colloid	colloid	pap ca	iso	iso	hypo reg	iso reg	fine coarse	no
86.	rekha	22	f	104419	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	hypo	no	no	no	no
87.	geetha	23	f	574	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	hypo	no	no	no	no
88.	usha	34	f	104481	colloid	pap ca	colloid	adenoma	iso	iso	no	hetero reg	comet	bbn
89.	rani	53	f	535	pap ca	pap ca	colloid	pap ca	iso	hypo	hypo reg	cystic irr	fine corse	bbn
90.	shantha	58	f	106332	colloid	colloid	colloid	colloid	iso	hypo	hyper reg	cystic irr	comet eggshell	bbn
91.	kamsala	40	f	497	thyroiditis	colloid	colloid	thyroiditis	iso	iso	no	no	no	bbn

92.	esther	46	f	553	thyroiditis	mng	colloid	thyroiditis	hypo	iso	no	no	no	bbn
93.	rosy	30	f	559	colloid	colloid	colloid	colloid	iso	iso	no	no	no	no
94.	hemalatha	12	f	1639	thyroiditis	colloid	colloid	thyroiditis	hypo	iso	no	iso reg	no	no
95.	shajitha	36	f	1634	pap ca	pap ca	pap ca	pap ca	iso	iso	hetero irr	hetero reg	fine coarse	no
96.	kamatchi	21	f	1628	colloid	colloid	colloid	colloid	iso	iso	no	no	no	no
97.	uma	40	f	1638	thyroiditis	adenoma	colloid	thyroiditis	hypo	iso	no	no	no	no
98.	malathy	43	f	1618	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hetero	hetero	no	no	no	no
99.	esther	46	f	145	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	no	no	no	no
100.	murugammal	32	f	2822	colloid	colloid	colloid	colloid	iso	iso	iso reg	iso reg	comet coarse	no
101.	thulasi	22	f	6859	colloid	colloid	colloid	colloid	iso	iso	iso reg	hyper reg	no	bbn
102.	thenmozhi	32	f	5660	colloid	colloid	colloid	thyroiditis	iso	iso	no	no	no	no
103.	vasanthi	32	f	5600	pap ca	colloid	colloid	OAH	iso	iso	hetero irr	no	fine coarse	bbn
104.	ponni	45	f	6815	colloid	colloid	colloid	colloid	iso	iso	hetero reg	hetero irr	coarse	bbn
105.	ramani	36	f	6818	colloid	colloid	colloid	colloid	hypo	iso	no	hetero reg	comet	no
106.	pushpammal	57	f	5610	pap ca	colloid	colloid	pap ca	iso	iso	iso reg	hetero reg	fine	no
107.	jayaseeli	33	f	5657	thyroiditis	thyroiditis	colloid	colloid	hypo	hypo	no	no	no	bbn
108.	krishnaveni	58	f	5610	pap ca	pap ca	colloid	pap ca	iso	hetero	hetero irr	hypo reg	fine	no
109.	narayanan	68	m	5645	thyroiditis	thyroiditis	colloid	colloid	hetero	hetero	hypo irr	cystic reg	comet	no
110.	jailani	39	f	5592	colloid	colloid	colloid	OAH	iso	iso	no	no	no	no
111.	philomina	50	f	5576	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hetero	hetero	hypo irr	hypo irr	no	no
112.	murugammal	32	f	2036	colloid	colloid	colloid	colloid	iso	iso	iso reg	iso reg	no	no
113.	sayed meera	29	f	7898	pap ca	colloid	colloid	pap ca	iso	iso	hypo irr	no	fine	no
114.	mangailakshmi	55	f	7908	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hetero	hetero	iso reg	iso reg	comet	no
115.	suguna	39	f	7894	colloid	colloid	colloid	colloid	iso	iso	iso reg	iso reg	no	no
116.	santhosh mary	33	f	9128	thyroiditis	mng	thyroiditis	thyroiditis	hypo	hypo	iso reg	iso reg	no	bbn
117.	manimegalai	62	f	9304	pap ca	colloid	colloid	pap ca	iso	iso	hypo reg	iso reg	fine coarse	bbn
118.	saroja	32	f	9149	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	hypo	iso reg	iso reg	no	no
119.	bhuvaneshwari	32	f	9103	pap ca	mng	papillary hyperplasia	pap ca	iso	iso	hypo reg	hetero irr	fine coarse	no
120.	savitri	43	f	9104	adenoma	pap ca	colloid	adenoma	iso	iso	iso halo	no	no	no
121.	kokilavani	19	f	9107	adenoma	snt	colloid	adenoma	iso	iso	no	iso halo	no	no
122.	karupayeammal	60	f	9112	colloid	colloid	colloid	colloid	hypo	iso	no	iso halo	no	no
123.	indira	39	f	10210	pap ca	mng	colloid	pap ca	hetero	hetero	hypo irr	no	coarse	no
124.	guruvammal	67	f	10228	pap ca	mng	colloid	pap ca	iso	iso	no	hetero irr	fine coarse	no

125.	sakunthala	57	f	10203	pap ca	pap ca	thyroiditis	pap ca	iso	iso	hetero irr	no	coarse	no
126.	laila	45	f	10267	colloid	colloid	colloid	colloid	iso	iso	iso reg	iso halo	no	no
127.	manjula	38	f	11361	pap ca	colloid	colloid	pap ca	hetero	iso	hypo irr	iso halo	coarse	no
128.	selin	39	f	11414	pap ca	colloid	colloid	oncocytic adenomatoid hyperplasia	iso	iso	hetero irr	no	fine coarse	no
129.	chitra	25	f	11423	colloid	colloid	colloid	thyroiditis	iso	iso	no	cystic irr	no	no
130.	amaravathy	50	f	12489	colloid	colloid	colloid	colloid	iso	iso	no	no	coarse	no
131.	sundari	25	f	12513	adenoma	colloid	colloid	adenoma	hetero	hetero	hypo reg	no	no	no
132.	salomi	45	f	13739	pap ca	colloid	colloid	papillary hyperplasia	iso	iso	hetero reg	no	fine coarse	no
133.	afreen	40	f	13618	thyroiditis	mng	colloid	thyroiditis	hypo	hypo	iso reg	iso reg	no	no
134.	vijaya	35	f	13652	colloid	adenoma	colloid	colloid	iso	iso	cystic irr	no	coarse	no
135.	vedavalli	39	f	13299	thyroiditis	colloid	colloid	thyroiditis	hypo	hypo	iso halo	hypo reg	comet coarse	no
136.	arasu	35	f	13606	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hetero	hetero	hypo reg	hyper reg	coarse	no
137.	chandraleka	50	f	14636	pap ca	snt	colloid	pap ca	iso	iso	no	hetero irr	fine	no
138.	philomina	50	f	13698	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	hypo	no	iso reg	no	no
139.	kumar	50	m	13716	thyroiditis	thyroiditis	papillary hyperplasia	thyroiditis	hetero	hetero	no	no	no	bbn
140.	yuvaraj	41	m	13993	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	iso reg	iso reg	no	no
141.	nagammal	26	f	11346	pap ca	snt	pap ca	pap ca	iso	iso	hetero reg	no	fine	rt bn
142.	mohanasundari	24	f	11395	pap ca	pap ca	pap ca	pap ca	iso	iso	hetero irr	no	fine	no
143.	suchitra	56	f	14949	pap ca	colloid	colloid	pap ca	iso	iso	hetero reg	hetero reg	coarse	no
144.	mumala bee	57	f	15840	colloid	mng	colloid	colloid	iso	iso	cystic reg	no	no	bbn
145.	vijaya	48	f	15849	colloid	colloid	colloid	colloid	iso	iso	hyper reg	cystic reg	comet coarse	no
146.	ezhilarasi	25	f	16983	thyroiditis	thyroiditis	colloid	thyroiditis	absent	hypo	no	no	no	no
147.	gajalakshmi	28	f	16980	colloid	mng	colloid	pap ca	iso	iso	no	cystic reg	no	bbn
148.	kasi	58	m	16263	pap ca	mng	colloid	pap ca	iso	iso	no	hetero irr	fine coarse	no
149.	kamala	54	f	18162	adenoma	snt	colloid	adenoma	iso	iso	iso halo	no	coarse	no
150.	karunakaran	50	m	17668	colloid	colloid	follicular neoplasm	colloid	iso	iso	cystic reg	no	comet	no
151.	vedavalli	39	f	19299	adenoma	snt	colloid	adenoma	iso	iso	iso halo	hypo reg	comet coarse	no
152.	anbhazagan	49	m	19614	colloid	colloid	colloid	colloid	iso	iso	hypo reg	cystic reg	comet coarse	no
153.	sudhadevi	25	f	20360	adenoma	colloid	colloid	adenoma	iso	iso	iso halo	hypo halo	coarse	no

154.	kokilaveni	19	f	20367	adenoma	snt	colloid	adenoma	iso	iso	no	iso halo	no	no
155.	murugammal	32	f	20364	pap ca	mng	colloid	papillary hyperplasia	iso	iso	hypo reg	cystic reg	coarse	no
156.	indira	42	f	20363	thyroiditis	thyroiditis	thyroiditis	thyroiditis	iso	hypo	hypo reg	no	coarse	no
157.	mangammal	40	f	19374	thyroiditis	colloid	colloid	thyroiditis	hetero	hetero	hypo reg	hypo reg	no	no
158.	sundari	40	f	20411	adenoma	snt	colloid	adenoma	iso	iso	iso halo	no	no	no
159.	buthamathi	51	f	21576	colloid	colloid	colloid	colloid	iso	iso	hyper reg	hypo reg	coarse	no
160.	mariyammal	35	f	21606	pap ca	snt	colloid	papillary hyperplasia	iso	iso	no	hetero irr	fine	no
161.	ezhilarasi	23	f	21577	thyroiditis	thyroiditis	colloid	thyroiditis	hetero	hetero	no	no	no	bbn
162.	dhanalakshmi	37	f	22805	colloid	mng	colloid	colloid	iso	iso	cystic reg	cystic reg	no	no
163.	asha	37	f	22791	adenoma	mng	colloid	adenoma	iso	iso	hypo reg	hetero reg	coarse	no
164.	kamaraj	42	m	22948	pap ca	pap ca	colloid	pap ca	iso	iso	hypo reg	hypo irr	fine coarse	no
165.	shanthi	36	f	23934	pap ca	mng	papillary hyperplasia	papillary hyperplasia	iso	iso	hetero reg	hetero reg	fine coarse	no
166.	prema	45	f	23913	pap ca	mng	colloid	adenoma	iso	iso	no	hetero reg	coarse	no
167.	murugammal	36	f	23950	colloid	colloid	colloid	colloid	iso	iso	cystic reg	cystic reg	coarse	no
168.	adhilakshmi	35	f	25115	thyroiditis	mng	colloid	thyroiditis	hypo	hypo	iso halo	no	no	no
169.	usharani	48	f	25098	colloid	colloid	colloid	colloid	hypo	hypo	iso reg	iso reg	no	no
170.	visalam	42	f	26175	pap ca	pap ca	colloid	pap ca	iso	iso	hypo irr	hypo irr	fine	no
171.	subashini	32	f	27357	thyroiditis	colloid	pap ca	thyroiditis	hetero	hetero	hypo reg	hypo reg	coarse	no
172.	chandra	65	f	27406	colloid	colloid	colloid	thyroiditis	iso	iso	iso halo	hypo reg	coarse	no
173.	selvi	25	f	27400	thyroiditis	mng	thyroiditis	thyroiditis	hypo	hypo	iso reg	iso hypo	no	no
174.	selvanayagi	24	f	28374	adenoma	mng	follicular neoplasm	adenoma	iso	hetero	no	iso halo	no	no
175.	dhanalakshmi	27	f	30472	pap ca	colloid	thyroiditis	pap ca	iso	iso	hetero reg	hypo reg	fine	rt bn
176.	vijaya	35	f	30465	thyroiditis	mng	papillary hyperplasia	thyroiditis	hetero	hetero	no	no	no	no
177.	janaki	45	f	30470	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hetero	hypo	hypo reg	no	eggshell	no
178.	maheswari	58	f	30488	adenoma	colloid	thyroiditis	thyroiditis	hypo	hypo	no	iso halo	coarse	no
179.	sampath	48	m	30473	pap ca	colloid	pap ca	pap ca	iso	iso	hetero irr	hetero irr	fine coarse	no
180.	gowthami	19	f	30474	colloid	colloid	pap ca	adenoma	iso	iso	cystic reg	no	no	no
181.	kasi	67	m	31556	pap ca	mng	colloid	pap ca	iso	iso	hetero irr	hetero irr	fine comet	bbn
182.	hemalatha	30	f	31554	adenoma	mng	colloid	colloid	iso	iso	hypo reg	iso halo	coarse	no

183.	easwari	38	f	31565	pap ca	snt	papillary hyperplasia	pap ca	iso	iso	no	hypo irr	coarse	no
184.	devaraj	33	m	31864	med ca mets	med ca mets	med ca mets	med ca mets	absent	iso	no	no	no	bmn
185.	gunasundari	25	f	33357	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	no	hyper reg	no	no
186.	shanthi	42	f	33445	pap ca	colloid	colloid	pap ca	iso	iso	no	hetero reg	eggshell	no
187.	anjalai	40	f	33479	pap ca	colloid	pap ca	pap ca	iso	iso	no	hypo irr	no	no
188.	prem kumar	53	m	35694	colloid	colloid	colloid	colloid	iso	iso	iso reg	iso reg	no	no
189.	arunachalam	56	m	33457	thyroiditis	snt	colloid	colloid	hypo	iso	no	hetero reg	coarse	no
190.	lalithakumari	19	f	34580	thyroiditis	colloid	colloid	thyroiditis	hypo	iso	hyper reg	hypo reg	no	no
191.	deepa	30	f	34609	thyroiditis	colloid	colloid	thyroiditis	hypo	hypo	hetero reg	hetero reg	comet	no
192.	sasikala	42	f	34621	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	hypo	iso halo	hypo reg	no	no
193.	jayanthi	28	f	35805	pap ca	pap ca	pap ca	pap ca	iso	iso	no	hetero reg	fine	no
194.	lavanya	37	f	38360	colloid	colloid	colloid	colloid	iso	iso	iso reg	hypo reg	no	no
195.	jayalakshmi	27	f	35798	pap ca	pap ca	pap ca	pap ca	iso	hypo	no	hetero irr	fine	lt bn
196.	dhanalakshmi	41	f	36934	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	no	hypo	no	no
197.	saraswathy	65	f	36870	pap ca	pap ca	pap ca	pap ca	iso	iso	hetero irr	hypo irr	fine coarse	bmn
198.	lakshmi	38	f	37955	colloid	colloid	colloid	colloid	iso	iso	cystic	no	coarse	no
199.	devi	28	f	37958	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	hypo	no	no	no	no
200.	thayarammal	40	f	37937	colloid	colloid	colloid	colloid	iso	iso	hypo reg	hetero reg	comet coarse	no
201.	geetha	46	f	39093	colloid	colloid	colloid	colloid	iso	iso	iso halo	hypo reg	coarse	no
202.	rajkumar	16	m	36869	colloid	colloid	thyroiditis	colloid	absent	hypo	no	no	no	no
203.	hemalatha	30	f	31554	colloid	colloid	colloid	colloid	iso	iso	iso reg	no	no	no
204.	lakshmanan	28	m	39069	thyroiditis	colloid	colloid	colloid	iso	hypo	hetero reg	no	coarse	no
205.	mary clara	28	f	40199	pap ca	mng	adenoma	pap ca	iso	iso	hypo irr	no	coarse	no
206.	mujibunnisa	21	f	40171	colloid	mng	colloid	colloid	iso	iso	hetero reg	no	comet coarse	no
207.	jaya	46	f	40236	adenoma	mng	colloid	adenoma	iso	iso	hetero reg	iso halo	no	lt bn
208.	nirmala	28	f	40234	colloid	colloid	colloid	colloid	iso	iso	hypo reg	hypo reg	no	bbn
209.	naji	30	f	40228	colloid	colloid	colloid	colloid	iso	iso	hetero reg	no	comet	no
210.	amudha	45	f	40245	colloid	colloid	colloid	colloid	iso	iso	cystic irr	no	coarse	rt bn
211.	chowdamma	20	f	40345	colloid	colloid	colloid	colloid	iso	iso	hypo reg	hypo reg	coarse	no
212.	rajendran	48	m	40367	colloid	colloid	colloid	colloid	iso	hypo	hetero reg	hypo reg	coarse	no
213.	vijaya	35	f	40260	thyroiditis	mng	colloid	colloid	absent	hypo	no	hetero reg	coarse	no
214.	devi	55	f	41325	pap ca	snt	colloid	pap ca	iso	iso	hetero irr	no	fine coarse	no
215.	prabha	32	f	43654	thyroiditis	mng	colloid	thyroiditis	iso	iso	hypo reg	hetero reg	coarse com	no

216.	kiruthiga	11	f	43636	pap ca	pap ca	pap ca	pap ca	iso	iso	hetero irr	no	fine coarse	bil mn
217.	rajeswari	37	f	43651	pap ca	colloid	colloid	papillary hyperplasia	iso	iso	hetero irr	hypo reg	fine coarse	rt mn lt bn
218.	navaneetham	34	f	43653	adenoma	colloid	thyroiditis	adenoma	iso	iso	heter reg	iso halo	comet	bbn
219.	maheswari	30	f	42594	med ca mets	med ca mets	med ca mets	med ca mets	absent	absent	no	no	no	lt mn
220.	angappa reddy	65	m	42506	colloid	colloid	colloid	pap ca	iso	iso	hetero reg	cystic irr	comet coarse	bbn
221.	amudha	45	f	40245	colloid	snt	colloid	colloid	iso	iso	cystic irr	no	coarse	rt bn
222.	sakunthala	34	f	42451	adenoma	adenoma	colloid	colloid	iso	iso	hypo halo	no	coarse	no
223.	mohana	22	f	42473	colloid	snt	colloid	colloid	iso	iso	cystic reg	no	coarse	no
224.	lakshmi	22	f	43892	colloid	colloid	colloid	colloid	iso	iso	iso reg	iso reg	no	no
225.	kasthuri	38	f	42487	colloid	colloid	colloid	colloid	iso	iso	cystic reg	iso halo	coarse	rt bn
226.	priyanka	17	f	44812	colloid	snt	colloid	thyroiditis	iso	iso	no	cystic reg	coarse	lt bn
227.	sampathammal	50	f	44857	colloid	colloid	pap ca	colloid	iso	iso	hetero reg	iso halo	coarse	no
228.	selvi	26	f	45938	colloid	mng	colloid	colloid	iso	iso	hypo reg	hypo reg	no	no
229.	muniammal	46	f	45960	thyroiditis	colloid	colloid	thyroiditis	iso	hypo	hypo reg	no	no	no
230.	padmavathy	43	f	45941	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	no	no	no	no
231.	lakshmi	32	f	45890	pap ca	pap ca	pap ca	pap ca	iso	iso	iso	hypo reg	fine coarse egg shell	no
232.	fathimuthu	30	f	47262	pap ca	pap ca	pap ca	pap ca	iso	iso	hetero irr	no	fine coarse	rt bn
233.	kalyani	32	f	47113	pap ca	pap ca	pap ca	pap ca	iso	iso	no	hypo reg	fine coarse	lt mn
234.	kasthuri	38	f	42487	colloid	adenoma	colloid	colloid	hypo	iso	no	hetero irr	eggshell	no
235.	swarnalatha	28	f	49562	colloid	colloid	colloid	colloid	iso	iso	cystic reg	cystic reg	no	no
236.	razia begum	40	f	49484	thyroiditis	colloid	colloid	thyroiditis	hypo	iso	cystic reg	iso reg	no	rt bn
237.	brindala	23	f	49519	adenoma	mng	papillary hyperplasia	adenoma	iso	iso	iso reg	iso reg	comet coarse	rt bn
238.	patchaiammal	38	f	47158	colloid	colloid	colloid	colloid	iso	iso	cystic irr	cystic reg	no	no
239.	meera	55	f	48219	colloid	snt	colloid	adenoma	iso	iso	cystic irr	no	no	bbn
240.	angel mary	45	f	48273	colloid	colloid	colloid	colloid	iso	iso	iso reg	cystic reg	comet coarse	no
241.	pushpa	75	f	49472	pap ca	pap ca	pap ca	pap ca	iso	iso	hypo	no	fine	no
242.	palani	40	m	43599	med ca	med ca	med ca	med ca	hypo	iso	hypo irr	hypo reg	coarse	rt mn
243.	govindammal	65	f	48646	pap ca	pap ca	pap ca	pap ca	iso	iso	hetero irr	hetero irr	fine coarse	bbn
244.	sasikala	30	f	50696	pap ca	colloid	colloid	pap ca	iso	iso	hypo reg	hypo irr	coarse	rt bn
245.	mahalakshmi	56	f	50670	thyroiditis	thyroiditis	colloid	thyroiditis	hetero	hetero	hetero reg	hetero reg	comet coarse	bbn
246.	chellaiah	70	m	50638	pap ca	pap ca	pap ca	papillary	iso	iso	hypo reg	hetero irr	fine coarse	lt mn rt

								hyperplasia						bn
247.	ramachandran	38	m	44824	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hetero	hetero	hypo irr	hypo irr	comet	bbn
248.	ashokkumar	21	m	50660	colloid	colloid	colloid	colloid	absent	hypo	no	no	coarse	no
249.	mani	51	m	51893	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	hypo	no	no	no	no
250.	deepan kumar	26	m	51962	colloid	snt	colloid	colloid	iso	hetero	hetero reg	no	coarse	no
251.	tamilarasi	46	f	53106	colloid	colloid	colloid	thyroiditis	iso	iso	no	hypo reg	no	no
252.	anbarasi	38	f	53076	colloid	colloid	colloid	colloid	iso	iso	no	hetero reg sep	coarse	no
253.	pavai	42	f	51906	pap ca	colloid	colloid	pap ca	iso	hetero	hypo irr	no	fine	no
254.	tamil selvi	28	f	51900	thyroiditis	mng	colloid	thyroiditis	hetero	hetero	hetero reg	hetero irr	coarse	bbn
255.	poornima	20	f	53077	pap ca	snt	colloid	pap ca	iso	iso	hetero irr	no	fine coarse	rt bn
256.	nirmala	52	f	54344	colloid	colloid	colloid	colloid	iso	iso	hetero reg	cystic irr	comet coarse	no
257.	yashodha	36	f	55467	pap ca	mng	colloid	pap ca	iso	iso	hypo reg	iso reg	fine	no
258.	sakunthala	52	f	55494	pap ca	colloid	colloid	pap ca	hetero	hetero	iso reg	hetero reg	fine coarse	no
259.	vanitha	35	f	55456	adenoma	adenoma	colloid	adenoma	iso	iso	hypo halo	no	coarse	bbn
260.	renuka	32	f	55451	colloid	colloid	colloid	colloid	hetero	hetero	no	hypo reg	coarse	no
261.	gomathi	28	f	55435	colloid	colloid	colloid	colloid	iso	iso	iso halo	iso halo	no	no
262.	sangeetha	32	f	59011	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hetero	hetero	hetero reg	hetro reg	no	bbn
263.	indrani	36	f	56692	pap ca	pap ca	colloid	pap ca	iso	hetero	hetero irr	hypo reg	fine coarse	no
264.	padmavathy	30	f	56706	thyroiditis	thyroiditis	colloid	thyroiditis	hypo	hetero	no	no	no	bbn
265.	vijayalaxmi	40	f	58970	thyroiditis	mng	thyroiditis	thyroiditis	hetero	hypo	no	no	no	rt bn
266.	malliga	35	f	58976	colloid	colloid	colloid	colloid	iso	iso	cystic reg	cystic reg	comet coarse	no
267.	uma maheswari	48	f	60152	thyroiditis	colloid	colloid	thyroiditis	hetero	iso	cystic reg	cystic reg	no	bbn
268.	sarasu	44	f	60162	colloid	colloid	colloid	adenoma	iso	iso	no	cystic irr	coarse com	lt bn
269.	shanthi	43	f	60161	colloid	colloid	colloid	colloid	hetero	hetero	hypo reg	cystic irr	comet	bbn
270.	shanthi	45	f	39088	pap ca	mng	colloid	pap ca	iso	iso	hypo reg	hypo irr	fine	no
271.	jasmine	34	f	61416	thyroiditis	snt	thyroiditis	pap ca	iso	hetero	hypo reg	no	no	no
272.	kanagavalli	55	f	61422	colloid	colloid	colloid	adenoma	iso	iso	no	cystic reg	comet	no
273.	saraswathy	23	f	61437	pap ca	mng	pap ca	pap ca	iso	iso	cystic	hypo reg	fine comet	no
274.	saroja	45	f	61335	colloid	colloid	colloid	colloid	iso	iso	no	hypo reg	no	no
275.	sumathy	37	f	60140	colloid	pap ca	thyroiditis	pap ca	iso	iso	no	cystic reg	no	lt bn
276.	revathy	50	f	61427	adenoma	mng	colloid	thyroiditis	iso	iso	iso reg	hypo halo	no	bbn
277.	vaidehi	20	f	69775	adenoma	mng	colloid	colloid	iso	iso	hypo	hypo halo	no	no
278.	estherrani	15	f	68758	colloid	colloid	thyroiditis	colloid	absent	iso	no	no	no	no

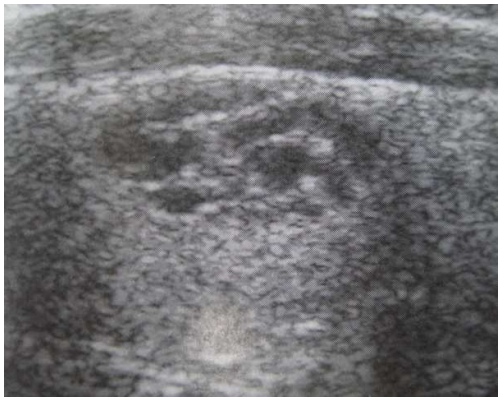
279.	jayanthi	35	f	67358	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	iso reg	iso reg	no	no
280.	vennila	28	f	63245	pap ca	pap ca	colloid	pap ca	iso	iso	hypo irr	heter irr	fine	rt mn
281.	revathy	50	f	61427	thyroiditis	mng	colloid	thyroiditis	hetero	hetero	hypo reg	hypo reg	no	no
282.	vijaya	38	f	61527	thyroiditis	thyroiditis	colloid	colloid	hypo	hypo	no	no	no	no
283.	devi	28	f	62627	colloid	mng	colloid	colloid	iso	iso	hypo reg	no	no	no
284.	jamuna	35	f	75444	thyroiditis	colloid	thyroiditis	thyroiditis	hypo	hypo	iso reg	iso reg	no	no
285.	priya	31	f	63730	pap ca	colloid	colloid	pap ca	iso	iso	no	hetero irr	fine	no
286.	kasthuri	32	f	49471	pap ca	adenoma	colloid	pap ca	iso	iso	hypo reg	heter irr	fine coarse	no
287.	vadivel	55	m	64681	adenoma	colloid	colloid	adenoma	iso	iso	iso halo	hypo reg	no	no
288.	vijayalaxmi	35	f	75479	colloid	pap ca	colloid	colloid	iso	hypo	cystic irr	no	coarse	bbn
289.	poongothai	23	f	69818	adenoma	colloid	colloid	papillary hyperplasia	hetero	iso	no	iso halo	comet coarse	no
290.	ambika	44	f	72174	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	iso reg	iso reg	no	no
291.	malathy	48	f	74290	thyroiditis	colloid	colloid	colloid	iso	hypo	cystic irr	no	no	no
292.	nirmala	50	f	74274	pap ca	colloid	colloid	pap ca	hetero	hypo	hetero reg	hetero irr	coarse	no
293.	saraswathy	34	f	73212	thyroiditis	thyroiditis	thyroiditis	thyroiditis	iso	hypo	no	no	coarse	no
294.	ezhumalai	60	m	68615	colloid	pap ca	pap ca	colloid	iso	hypo	no	iso reg	no	no
295.	daisy	37	f	77685	colloid	colloid	colloid	colloid	iso	iso	hypo halo	no	no	no
296.	sumathy	27	f	68580	pap ca	pap ca	colloid	pap ca	iso	iso	no	hetero irr	fine coarse	lt bn
297.	kamatchi	55	f	77672	pap ca	mng	colloid	pap ca	iso	iso	cystic reg	hetero irr	fine coarse	no
298.	kittappa	37	m	74276	pap ca	colloid	colloid	papillary hyperplasia	iso	iso	hetero reg	hetero irr	coarse	ltbn
299.	sivakumar	27	m	74265	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	iso	iso	no	no
300.	jayamary	55	f	84500	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hetero	hetero	heter reg	hypo halo	no	bbn
301.	saroja	65	f	84518	pap ca	pap ca	colloid	pap ca	iso	iso	hypo irr	hypo reg	fine coarse	rt mn
302.	chamundeswari	22	f	84535	colloid	pap ca	colloid	colloid	iso	iso	no	cystic reg	no	lt bn
303.	kuttimma	35	f	84559	colloid	colloid	colloid	colloid	iso	iso	hypo reg	hypo reg	coarse	no
304.	suryakala	45	f	79850	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	iso reg	hyper reg	coarse	no
305.	thillaivanam	45	f	85706	colloid	colloid	colloid	colloid	iso	iso	hypo reg	cystic irr	comet coarse	no
306.	chandra	50	f	83341	pap ca	colloid	colloid	pap ca	iso	iso	no	hypo irr	coarse	no
307.	uma	23	f	80960	thyroiditis	colloid	colloid	colloid	hetero	hetero	no	hypo reg	no	no
308.	parvathy	57	f	79823	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	no	no	no	bbn
309.	kasthuri	50	f	85702	adenoma	mng	follicular	adenoma	iso	iso	hypo halo	no	coarse	no

							neoplasm							
310.	dhanapal	75	m	63875	pap ca	pap ca	colloid	pap ca	iso	iso	hypo irr	hetero irr	fine coarse	no
311.	rajakumari	45	f	86816	colloid	colloid	colloid	adenoma	iso	iso	cystic reg	no	comet	no
312.	jayalakshmi	50	f	86883	thyroiditis	mng	colloid	thyroiditis	hypo	hetero	iso	hypo reg	no	no
313.	valliammal	60	f	80915	pap ca	mng	colloid	pap ca	iso	hypo	no	no	fine	lt mn
314.	thangam	32	f	84585	thyroiditis	mng	thyroiditis	thyroiditis	hypo	hypo	no	iso reg	coarse	no
315.	surya	23	f	87375	colloid	pap ca	colloid	pap ca	iso	iso	cystic reg	no	coarse	no
316.	deepa	19	f	86701	colloid	pap ca	colloid	thyroiditis	iso	iso	cystic reg	no	no	no
317.	saranyan	16	m	45995	colloid	colloid	colloid	colloid	iso	iso	iso reg	iso reg	no	lt bn
318.	kanchana	29	f	89706	thyroiditis	colloid	colloid	colloid	hypo	iso	cystic reg	no	coarse	no
319.	uma maheswari	40	f	89039	pap ca mets	pap ca mets	pap ca mets	pap ca mets	iso	iso	no	hetero irr	fine coarse	rt bn lt mn
320.	prathiba	32	f	88010	colloid	mng	colloid	colloid	iso	iso	hypo reg	cystic reg	comet coarse	lt bn
321.	dhanasekar	42	m	87985	thyroiditis	thyroiditis	pap ca	thyroiditis	iso	hypo	no	iso reg	no	lt bn
322.	sheela	32	f	91350	pap ca	pap ca	pap ca	pap ca	iso	iso	no	hetero irr	coarse	lt mn
323.	vedamma	40	f	91305	colloid	colloid	colloid	colloid	iso	iso	cystic reg	no	comet	no
324.	ilanjiyam	45	f	91302	colloid	snt	pap ca	colloid	iso	iso	hypo reg	no	coarse	no
325.	arpudham	38	f	88214	pap ca	pap ca	pap ca	pap ca	iso	iso	no	hetero irr	fine coarse	rt bn lt mn
326.	sivagami	39	f	87960	colloid	adenoma	colloid	colloid	iso	iso	cystic reg	hetero reg	comet coarse	lt bn
327.	angammal	45	f	94563	colloid	mng	colloid	colloid	iso	iso	iso reg	cystic reg	comet coarse rt bn	rt bn
328.	parimala	40	f	99479	colloid	colloid	colloid	colloid	iso	iso	no	cystic reg	no	bbn
329.	pramila	45	f	99721	colloid	colloid	colloid	colloid	iso	iso	no	cystic reg	no	no
330.	manjula	22	f	94486	adenoma	colloid	colloid	adenoma	iso	iso	no	hypo reg	coarse	no
331.	thilagam	39	f	97512	adenoma	mng	colloid	adenoma	hypo	iso	iso halo	hypo reg	no	no
332.	balammal	60	f	97048	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hypo	hypo	no	iso reg	no	no
333.	anwar basha	27	m	98690	pap ca	adenoma	colloid	pap ca	iso	iso	hetero irr	no	fine coarse	no
334.	govindan	32	m	98717	adenoma	adenoma	thyroiditis	colloid	iso	iso	no	iso reg	no	no
335.	vijayalaxmi	34	f	98684	adenoma	snt	thyroiditis	adenoma	iso	iso	hypo halo	no	coarse	no
336.	rajeswari	55	f	104676	pap ca	mng	colloid	pap ca	iso	iso	hypo reg	hetero irr	fine coarse	no
337.	thangammal	62	f	103458	colloid	colloid	colloid	adenoma	iso	iso	iso reg	hypo reg	no	no
338.	vijaya	40	f	102293	thyroiditis	thyroiditis	thyroiditis	thyroiditis	hetero	hetero	no	no	no	no
339.	chellammal	65	f	104567	colloid	colloid	colloid	colloid	hypo	hypo	no	cystic reg	no	no

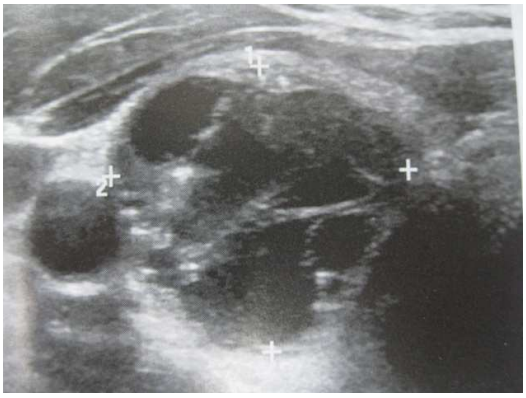
340.	mobishara begum	19	f	102406 pap ca	pap ca	pap ca	pap ca	pap ca	iso	iso	hypo hetero	hypo reg	fine coarse	rt bn
341.	navaladi	40	m	104552	pap ca	pap ca	pap ca	pap ca	iso	iso	hypo irr	hypo reg	fine coarse	bbn
342.	sekar	51	m	86048	pap ca mets	pap ca mets	pap ca mets	pap ca mets	iso	hypo	hypo reg	hetero irr	fine coarse	lt mn
343.	pattu	70	f	111171	pap ca	pap ca	pap ca	pap ca	iso	iso	hypo irr	no	fine	no
344.	mohana	45	f	101019	pap ca	mng	thyroiditis	pap ca	hypo	iso	iso reg	hetero irr	fine coarse	no
345.	amudhavani	46	f	100942	colloid	colloid	pap ca	colloid	iso	iso	iso halo	cystic reg	no	no
346.	radha	54	f	102340	thyroiditis	thyroiditis	colloid	colloid	iso	iso	hetero reg	hetero reg	comet coarse	lt bn
347.	chellammal	65	f	104567	colloid	mng	colloid	colloid	iso	hypo	iso reg	cystic reg	no	no
348.	subramani	53	m	107790	pap ca	mng	pap ca	pap ca	iso	iso	hetero irr	hypo reg	fine	rt mn
349.	kamala	65	f	108973	pap ca	pap ca	thyroiditis	pap ca	iso	iso	hypo reg	hetero irr	fine coarse	bbn
350.	habeeba	28	f	85097	pap ca mets	pap ca mets	pap ca mets	reactive nodes	absent	absent	no	no	no	bmn

FIGURE 1

LIKELY BENIGN PATTERNS

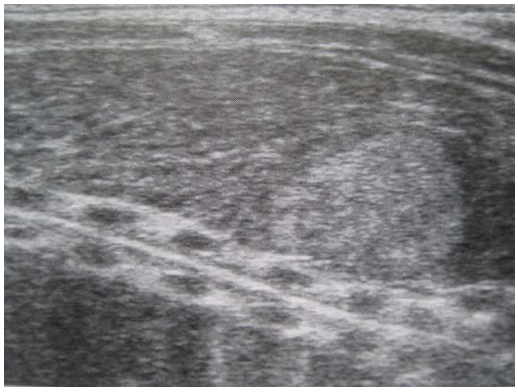


Cystic nodules without internal echogenic foci



Large predominantly cystic nodule with comet tail

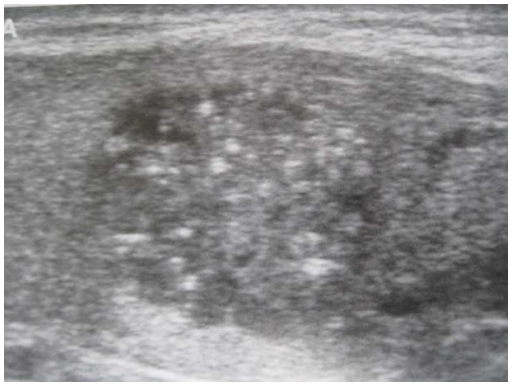
Honey comb or Spongiform pattern



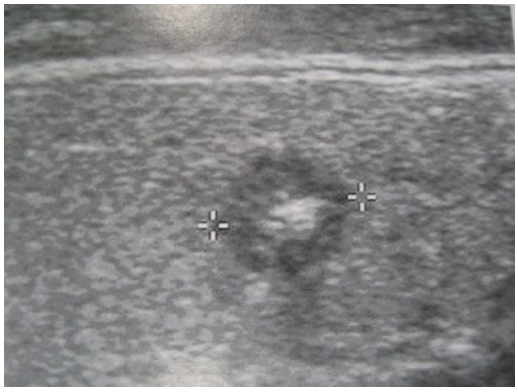
Markedly hyperechoic nodule

FIGURE 2

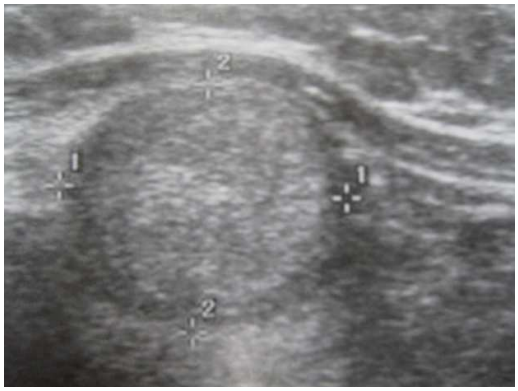
WORRISOME PATTERNS



Hypoechoic nodule with echogenic foci



Hypoechoic nodule with Coarse calcification



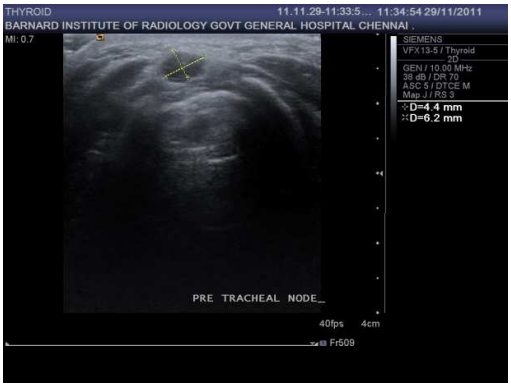
Refractive shadow from the edge of the lesion

Egg shaped nodule with a thin capsule

FIGURE 3

PAP CA

Hypoechoic nodule with fine calcifications



Pretracheal node with loss of fatty hilum

Level 3 Node with calcifications

Cystic node